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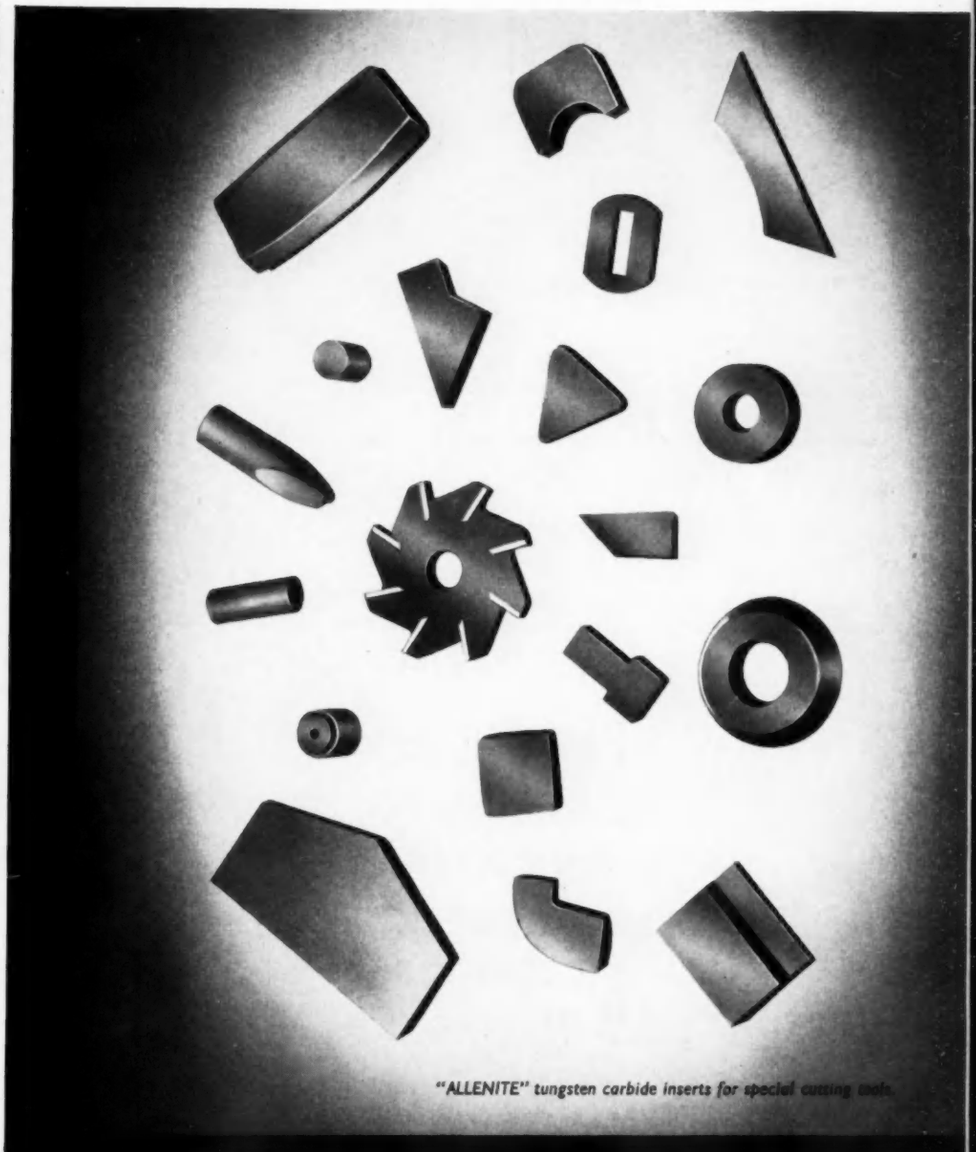

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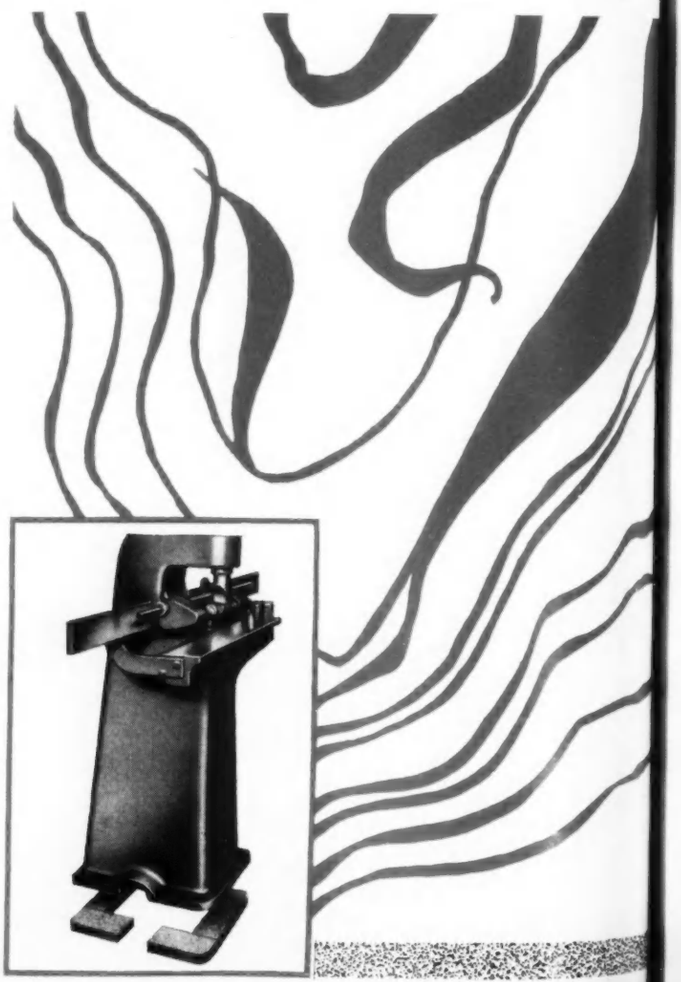

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THE ENGINEER

No. 5517 OCTOBER 20, 1961 Vol. 212

NUCLEAR PROPULSION OF SHIPS?

At the annual James Watt Dinner of the Institution of Engineers and Shipbuilders in Scotland held in Glasgow last Friday night, October 13, the main topic of the speeches was that of the nuclear propulsion of ships. Sir William Cook, who is the development and engineering member of the Atomic Energy Authority and who proposed the Toast of the Institution, explained quite bluntly how unattractive, economically, is nuclear propulsion for merchant ships. The cost of nuclear engines would need to be halved and fuel bills cut by a third before they could compete with conventional steam turbines. He did not, of course, suggest that there was anything impossible about doing so eventually but he did regard it as a "stiff target to face". Reactors for lower capital and fuel costs are being studied and he seemed to hint that lower standards of shielding and of collision protection might have to be accepted in order to get costs down. In any case he stressed that quick results should not be expected from researches now going forward towards the development of less costly reactors. He hoped, of course, that the Government would finance research into nuclear propulsion.

Mr. Walker, a vice-president of the Institution, in reply, was much more forceful. In effect he said that the Government had had plenty of time to make up its mind whether or not to finance research and that it should announce its policy at once. So long had been the delay that shipbuilders and marine engineers were beginning to ask whether they ought to give up the whole idea and disperse nuclear design teams or alternatively attempt to pursue the subject on their own. All concerned with ships and shipbuilding are likely to sympathise with Mr. Walker. Hesitation by the Government can of course, be well understood but answers to some pertinent questions are urgently needed. Is it worth while to divert a proportion of scarce research resources to the building of what Mr. Walker called a "floating laboratory" when it seems so very dubious whether a nuclear propelled vessel could become economic within a decade or more? Would it be sufficient to gain experience of nuclear propulsion in some of H.M. submarines? Should development of nuclear propulsion for surface ships be left to the Royal Navy, for whose purposes it has the special advantage of conferring almost unlimited endurance at high speed? And so on. But hesitation can be too prolonged. Would it not be better to decide upon a definite policy now, even though the future might prove it to have been in certain respects ill-chosen, than to have no policy at all? In our view—and surely that of most shipbuilders and marine engineers too—the Government of a seafaring and shipbuilding nation ought to ensure, in so far as it can, that the nation leads the world in the technical development of marine propulsion. Even a decision to contribute not one penny to research into nuclear propulsion would clear the air!

ELECTRICAL EXPORTS

Exports of British electrical goods in the first six months of this year were 10·7 per cent more than in the first half of 1960. If this rate of progress is maintained it seems certain that these exports will substantially exceed £300 million in 1961. But that these encouraging prospects are viewed as a challenge, rather than a cause for complacency, was evident from the recent Golden Jubilee Export Conference of The British Electrical and Allied Manufacturers Association (BEAMA). Firms which have been wearied by repeated exhortations by government spokesmen to increase exports probably derived more practical help from the down-to-earth advice offered to the conference by Sir William McFadzean, chairman of the Export Council for Europe. Sir William, who believes that there is no substitute for hard salesmanship, suggested that absolute priority should be given to visits by top executives, who can thus assess opportunities at first hand, and to return visits by carefully chosen missions from European countries to see the scope and ability of British industry. The first part of this advice is by no means new. Two outstanding examples may be mentioned: Lord Nelson of Stafford and the late Sir Claude Gibb showed, independently, the supreme effectiveness of men with the power of decision to do business on the spot.

Some useful ideas emerged from the deliberations of the five groups into which the 300 delegates divided to discuss specialist aspects of exporting, on the second day of the conference. For example, it was suggested that the larger firms in the industry, who were already established in overseas territories, might offer the services of their own organisations to help the smaller manufacturers to market his products overseas. In exploring the European Common Market it was thought that the larger firms, operating through the BEAMA,

could help by the pooling of market information. Similarly, in the field of publicity, there seemed to be considerable scope for collaboration by groups of firms having interlocking interests, in staging collective displays at overseas exhibitions and trade fairs and in exploiting co-operative advertising and prestige literature and films. Here again, the sharing, on a wider basis, of up-to-date experience in export publicity should benefit the industry as a whole.

Enlightened self-interest will suggest ways of implementing ideas such as those outlined but the industry's efforts will be stultified unless the government can help by improving trading conditions. As Mr. Anthony Browne, president of BEAMA, reminded the conference, the aim of economic planning should be to substitute stability for short-term expediencies. On the one hand the nationalised industries, as well as the manufacturers who supply their plant and equipment, needed a stable investment plan for five years ahead. On the other hand makers of consumer goods could compete successfully in exports, only if they were allowed "to plan for efficient large-scale production without the fear that their basic home market would be upset by sweeping changes in credit controls". The "stop-and-go" expedients, applied so frequently in recent years, inevitably cause dislocated production and increased costs which handicap the exporter.

STANDARDS FOR SIGNALLING EQUIPMENT

Once it was possible to identify individual railways by the design of their semaphore signals and signal boxes. To-day the anonymous colour-light is shared by all the Regions, and the minor differences of styling reflect the individual manufacturer's practice rather than the whims of different signal engineers. This uniformity at the lineside is not yet matched inside the signal box. Here the varieties of style due to different manufacturers seem to be more pronounced, and there may be some way to go before unanimity is reached on the best way of arranging controls and indications for those who must work with them. Two general tendencies are emerging, however. One of these is the incorporation of train describer information with the track diagram. The other is similar in principle, being the transfer of the control switches to the diagram instead of grouping them below it. Both practices were seen by members of the Institution of Railway Signal Engineers during their annual technical visit this year, when the signal boxes at Sandbach and at Edge Hill were inspected. These are on the Crewe–Manchester and the Crewe–Liverpool sections of the high voltage a.c. electrification now in progress in the London Midland Region. Sandbach is controlled by a switch console below the diagram, similar to the boxes at Wilmslow and Manchester which came into service at the same period; while Edge Hill, opened this year, has entry/exit push-buttons mounted on a miniature route-setting panel from which one signalman can control some 170 routes.

At both these boxes the train descriptions are shown on the panels by optical projection indicators at the places where signals are represented, so that the class and destination of a train approaching any signal can be seen at once. This is a growing practice, and since differences are mainly in the mechanism of display — one Region uses an indicator of cyclometer form, for example—they do not affect the signalman. There is less uniformity, however, in the manner in which routes set up and track circuits occupied are indicated on signalling control panels to-day. Perhaps this must wait until designs of panels and controls are stabilised more than they have been so far. The trend towards compact panel layouts has made much redesign of components necessary and brings the opportunity for new thoughts on old practices. In one recent panel, for example, the same miniature light units delineate a route which has been selected and then show the progress of a train though it, by change in colour as successive track circuits are occupied. In this instance magenta has been chosen for the "occupied" indication to avoid confusion with the red lights on the panel repeating signal aspects. Such details deserve as much study as is given to the design of industrial control panels. In fact the signalman has much more manipulation to do than other control room operators, and the consequences of confusion are likely to be more catastrophic. It seems, also, that uniformity of practice would assist mobility of staff between signal boxes and even Regions. In other directions it might lead to economies in manufacture, particularly in items such as signal post telephones required in increasing numbers as power signalling proceeds. All departments of railway signalling are subject to change at the present time. With a.c. electrification, for example, it becomes possible to take emergency power from the traction supply, converting the single-phase current by static means to three-phase for driving the compressor motors used for electro-pneumatic point operation. Changeovers from normal to standby power can now be made in as little as one-fifth of a second so that a driver approaching a colour-light signal at such a moment would barely be aware of the transition being made. While some stress has been placed recently on preserving railway individualities, signalling is a field in which the claims of safety and economy in working should encourage uniformity of practice.

ACTIVITY IN OPERATIONAL RESEARCH

Last week we attended a meeting to introduce a recently formed company, Science in General Management Ltd. (SIGM) which has been formed "to offer advice on matters of management strategy in all degrees of complexity" to shy firms, industries or nationalised industries that want it. Much of the work of the new company is intended to have the character of operational research; and if it can put operational research across to industry more forcefully than has been done by anyone so far, it will have done good. But unfortunately we were not very impressed by the way O.R. was put across to those present at the meeting. The approach was as

much emotional as scientific, especially in attacking British industry for its lack of interest relative to that shown (according to the speaker) elsewhere in the world. Furthermore the appeal to actual figures, which is surely more likely to prove convincing to hard-headed managements, was based, not on post-war, but on wartime achievements. Frankly we doubt whether those achievements carry much weight. For compared to those of peacetime the problems of war seem rather simple; because the object of any exercise can usually be defined with great accuracy — to kill more submarines with fewer aircraft, for example. Besides it can be argued that the forces are disciplined so that they cannot go slow or strike and equipment available is limited. In fact possible courses of action are circumscribed and analysis thereby simplified. What is needed to put the idea over convincingly to businessmen is actual figures about what has been done in peacetime despite the apparent complications (on which in reality O.R. can often thrive). We hope when it comes to approach actual firms SIGM will do better. Some British managements are undoubtedly backward; but many, especially those with technical people on their boards of management are not — they are merely hard-headed. They will ask does O.R. really pay? Would any O.R. enthusiast dare to claim that it always does? The way to carry conviction is to cite up-to-date facts and figures; not to make insufficiently supported claims and then to accuse firms of being backward because they do not at once adopt O.R. methods.

THE GAS INDUSTRY

The report of the Gas Council for the year ending March 31, 1961, which has just been issued, shows that as a whole the gas industry had a surplus of more than £2,039,000 over the year and only four of the twelve area boards had deficits on their year's working. The gross income of the industry was £401,900,000, and this sum resulted from gas sales to the value of £236,800,000; coke and breeze sales at £80,200,000; other products £20,900,000; appliances £40,800,000; and other sources £18,100,000. Domestic consumers accounted for about 48·5 per cent of the total sales of 2,665,000,000 therms whilst industrial consumers used nearly 32 per cent and commercial consumers over 15 per cent. The average income per therm of gas sold was 21·32 pence as compared with 20·83 pence the previous year.

In presenting the report to the Press Sir Henry Jones, chairman of the Gas Council, said that the actual costs of producing gas had gone down for two years running. He predicted a continuing reduction in production costs if inflation did not occur, whilst at the same time an increase in gas consumption would further reduce the costs. Sir Henry gave no indication, however, of any likelihood of a reduction in the price of gas to the consumer—a reason being the call made in the recent White Paper "The Financial and Economic Objectives of the Nationalised Industries" for larger surpluses to be earned than in the past.

The report concludes with the somewhat obvious statement that price is the dominant feature in extending the market for gas and that the industry's continued expansion will rest upon its ability to contain rising costs. To this end "vigorous efforts" were being made to develop new and cheaper methods of gas production, and the section of the report on research notes that a number of projects with this object are now in or nearing the pilot plant stage. During the year under review expenditure by the Gas Council on research, testing and development work totalled £1,449,734; area boards spent £542,716 and made a £285,660 capital expenditure on behalf of the Council. That this relatively small amount (incidentally an "all time high") should be spent by an industry with an annual income of £400,000,000, and urgently needing to lower its production costs, suggests that the "vigorous efforts" received disproportionate financial backing.

The Engineer—100 Years Ago

The Channel Tunnel

Truly the Channel tunnel is an evergreen subject. In October, 1861, we reviewed a little book (of fifty pages) entitled "The Channel Railway, connecting England and France," by James Chalmers. As the author admitted that he was not a professional engineer and had no literary pretensions we felt that "... we need not criticise it very minutely." The author proposed to use a strong iron tube, which would be supported at the bottom of the sea by its own buoyancy, and kept down on the Channel bed by anchors or boxes of stone attached to it; the boxes and tube were to be covered by an embankment of rough stone. There were to be three ventilators, one in mid-Channel and one about a mile from each shore. Flues were to connect the centre ventilator with a chimney "... rising nearly 300ft above the level of the roadway at the middle," while the other ventilators were to have 200ft chimneys. Powerful machinery was to be employed "... if necessary, to force air to the parts most distant from the ventilators."

The author had an ingenious plan for joining the tubes under water. Each length of tube was to be fitted with temporary internal watertight bulkheads near the extremities, and a guide chain passed through a hole in the flange of a tube section already laid was to be used to draw another length into position. The water between the temporary bulkheads would then be withdrawn by opening a valve in the bulkhead of the last sunk tube, thus allowing hydrostatic pressure to force the two close together. Workmen would then pass through the tube previously fixed, and bolt the flanges of the two together. The estimated cost was £12,000,000.

We did not believe "... that this preliminary nice adjustment of the ends of such immense tubes, at great depths, could be sufficiently relied upon" and pointed out that unless the tubes could be brought together "with great nicety" before the valve was opened, the effect of opening it would simply be to let water in from outside. As to the marvellous influences the author predicted as stemming from a Channel railway, we felt that we should be better able to think about these things when we were more satisfied with the engineering part of the plan.

The Complete Car

Last week the Chairman's Address to the Automobile Division of the Institution of Mechanical Engineers was delivered by Mr. Donald Bastow, B.Sc.(Eng.), M.I.Mech.E., under the title "The Importance of the Design Stage." We reproduce here the text and some of the illustrations devoted to the subject named in our title.

THE complete car is too large a field to cover comprehensively and I can only refer to some of the things I personally find more interesting.

My period at Rolls-Royce left me with an idea of how I would go about the design of a suspension system for a complete car, and with a knowledge of at least the major features which would have to be considered in such a job and between which an acceptable compromise would have to be achieved. I had done various other jobs of design at Rolls-Royce, but the system of compartmenting in force there, meant that engines, gearboxes and, latterly, rear axles had been outside my scope. I took as much interest as possible in the rest of the car and we always had very full discussions about current developments—sometimes fuller among my contemporaries on design than with our seniors, but it was all instructive! It was not, however, until I went to Lagonda that I became more personally involved in the car as a whole. Mr. W. O. Bentley had a wealth of experience and a willingness to learn from it, and the six years with him were, I think, the most broadly educational of any I have had.

Design Requirements

The process of designing a motor car must start with formulating the requirements—passenger and luggage space and performance. It is I think axiomatic that the ride must be as good as possible consistent with other requirements (size and price, for instance) and that handling and control must be first class—or better! It seems to me logical also to encompass the desired capacity in the smallest and lightest envelope which can be wrapped round it. Starting with the passenger and luggage space, it is necessary to have a rough idea of overall size and weight before the probable performance can be estimated, and to know overall size and weight it is necessary to know how much room and weight must be allowed for the major components. Designing to a specification—the only commercially valuable kind—is therefore a process of successive approximations ; the nearer the first, the fewer the steps, and the further the process can be taken in the design stage the shorter and cheaper it will be. This is well-known to the practitioner—the fewness of them must be my excuse for talking about what to them is obvious.

This process depends on experience, and acquiring enough knowledge of empirical methods to allow quick calculations of weight and performance to be made. The weight analysis of existing cars is a well-known tool to give data for approximation about component weights for a proposal ; similarly, analysis of performance is the basis for estimation of what is required to give it, and the broader the field of results which can be tapped the better the basis, assuming reasonable accuracy in that field.

The bases of car performance are what the engine will give and what wind and rolling resistance will absorb. An engine is merely a means of breathing and burning air and extracting from the heat released in the burning as much useful work as possible.

Engine Performance

My paper on petrol engine performance and weight[1] was an attempt to arrive at a largely empirical basis for the maximum power which an engine of given dimensions and type could be expected to develop after a reasonable period of improvement. Because of the empirical basis one must always be prepared to modify either the methods or the figures of the paper in the light of further experience. Estimation of reasonable performance is useful both in starting the design of future vehicles and in deciding whether an existing engine has already arrived at a stage when future development work is unlikely to be profitable. An interesting extension is the possibility of arriving at a complete power curve for a proposed engine, and for this purpose it is necessary to have an i.m.e.p. curve. The best basis on which to plot this would appear to be conventional gas velocity somewhere in the inlet tract—preferably I think at the valve seat, since all the other parts are more easily varied or less limited. Ideally, one wishes to maintain as high an i.m.e.p. as possible over as large a speed range as possible. Variations are produced by the inherent freeness of breathing of the engine, the valve timing, and the effect of the inlet and exhaust systems. In my paper I had suggested maximum i.m.e.p.'s for different compression ratios and valve arrangements, and to make the curves of Fig. 1, relating

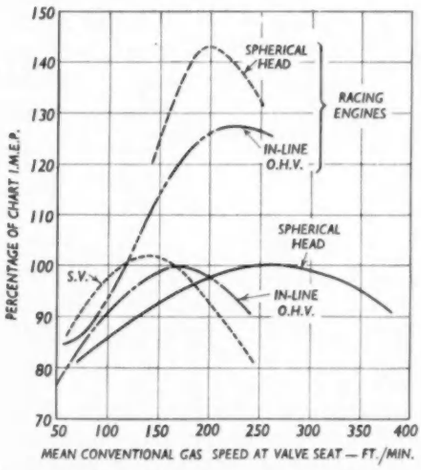

Fig. 1—Variation of i.m.e.p. as percentage of expected figure with mean gas speed.

to different breathing arrangements, more directly comparable, they have been plotted as percentages of the chart figure applicable against conventional mean gas speeds at the valve seat. On the small number of curves plotted, which are for engines in production form, it is reasonable to say that the part-spherical inclined valve-head does maintain its i.m.e.p. over a broader speed band than either in-line overhead-valve (o.h.v.) or side-valve engines. The value of this becomes more obvious when one considers the application of engines to vehicles.

The influence of inlet and, more particularly, exhaust systems, and valve timing, are shown by the two curves of Coventry Climax racing engines, the F.W.A. in-line o.h.v. engine and the twin o.h. camshaft 2½ litre F.P.F. The shape of the curves suggests that the F.W.A. valve timing is less extreme than that of the F.P.F. It has probably the freest breathing of any in-line valve engine. Since the chart figure for part-spherical heads is equivalent to a volumetric efficiency of 74 per cent, the maximum i.m.e.p. of the F.P.F. is equivalent to a volumetric efficiency of 105 per cent. For this particular engine friction mean effective pressures have probably been over-estimated. Other factors do come in, however, which are referred to in my paper. Anyone who feels like pursuing this technique for himself can of course most usefully do so over a period with figures from his own engines with his own exhaust layouts, valve timings and so on.

I feel unwilling to leave this whole question of engines without a plea for looking at it, in terms of new designs, purely from the point of view of how small, light and cheap a package can give the required performance, rather than asking if push rods are cheaper than twin overhead camshafts and their drives, or whether one carburetter on a six-cylinder engine is cheaper than two, and so on.

I find prediction of car performance is best studied by considering tractive efforts and resistances in pounds per ton. The time for acceleration over, say, a 10 m.p.h. gap is then a constant divided by the mean margin between tractive effort and total resistance curves. Moreover, the effect of gradient can be clearly seen by plotting replicas of the resistance curve at suitable elevations above that for level going. Accelerations in the lower gears are increasingly affected by the rotating inertias ; although it is a temptation to allow for these by progressively lower "efficiencies" in the lower gears, this falsifies the indications of steady-speed hill climbing capabilities, and it seems better therefore to be realistic with efficiencies in the different gears and use modified constants (preferably based on the effective rotating inertias concerned) in the lower gears.

Rolling resistance.—It is now well-known that rolling resistance is not a constant. The German "Continental" tyre people published a formula before the 1939–45 war for tyre resistance which, converted into English units, is :

$$R_T = \frac{1}{p^{0\cdot 64}}\left\{245\cdot 6 + \frac{v3\cdot 7}{397p^{1\cdot 44}}\right\}$$

where R_T is the rolling resistance, lb per ton ; p the tyre inflation pressure, lb per square inch, and v the speed, mile per hour.

This seems to be an idealised curve taking account of the rapid rise in resistance with speed when the tyre develops a standing wave. Although true figures will depend on tyre size, inflation, tyre construction, load carried and so on, it is useful to have an approximate curve for a first investigation, and arriving at one is a matter of individual sorting out for the likely range of conditions. It must include chassis friction.

At any given time, for cars which follow current trends in shape, there is less difference between different cars in air resistance coefficients than might be expected, and for a first approximation again an average figure can be used. Now that M.I.R.A. have wind tunnels one can fairly soon arrive at more accurate figures as a project takes shape.

In-line overhead valve or part-spherical head.—To illustrate the method and give a comparison between alternative engines with in-line o.h.v. and part-spherical combustion chambers, alternative four-cylinder engines

to give 80 h.p. were worked out by the methods of my paper, based on 8·0 : 1 compression ratio and a common stroke of 70mm—about the shortest practicable for this engine size. The in-line valve engine would need a bore of 3·75in and have a capacity of 122 cubic inches (2 litres), peaking at 4600 r.p.m. while the part-spherical head engine would achieve the same power from 94 cubic inches (1·53 litres) capacity peaking at 5700 r.p.m. By the methods of my paper it should be some 73 lb lighter as an engine-gearbox unit. These engines have been applied to a hypothetical car of 24 cwt kerb weight : the same indirect ratios have been used in each case, and the gearing chosen for top gear is on the basis of the same maximum tractive effort in each case. The differences in favour of the part-spherical head engine on this basis are fairly small but worth while, consisting of slightly higher maximum steady speeds on gradients and increases in tractive effort available for accelerating at the extremes of the speed range in any gear of up to 9 or 10 per cent. The wider speed range over which brake mean effective pressures are maintained in the part-spherical head engine prompts the thought that it might offer as good a performance with a three-speed gearbox as the in-line o.h.v. engine with a four-speed box.

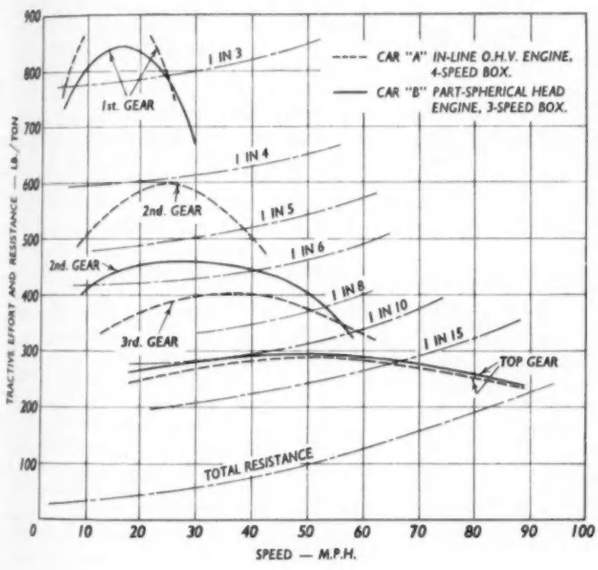

Fig. 2—Tractive effort and resistance curves.

This is investigated in Fig. 2. The major difference lies in the 30–40 m.p.h. range when in both full power hill climbing speeds and acceleration the three-speed gearbox car is inferior ; it has advantages at other parts of the speed range which would go some way to counterbalance this deficiency.

There are of course other advantages of the part-spherical head engine with inclined valves operated by twin overhead camshafts ; these are superior valve and valve seat cooling, longer exhaust valve and seat life without regrinding, lower stressed valve-gear compared with push-rod operation and hence reduced scuffing and wear problems, and the possibility of maintaining seating speeds over a wide range of speeds and temperatures without problems on cam ramps, and hence more easily achieved and maintained quietness.

Where an engine has a brake mean effective pressure curve maintained over a wide speed range it is clear from the tractive effort diagrams for a four-speed gearbox that the gaps between the tractive effort curves for the different gears and the hyperbola which would result from an infinitely variable gear of the same overall efficiency, are quite small. In one instance for which I made the calculation a drop in overall transmission efficiency of 3 per cent would have brought the acceleration time to maximum speed of a vehicle fitted with an infinitely variable gear to the same figure which could have been obtained with a four-speed gearbox, allowing one second for each gear change.

Automatic transmission.—This makes it clear why the overall efficiency of automatic transmissions is critical if there is to be no loss in accelerating or hill climbing performance. To maintain also the best fuel consumption it is necessary to have a control characteristic for an infinitely variable gear which will permit the engine to operate as far as possible in the range of its maximum thermal efficiency. The engine characteristics which must be taken into account in studying this aspect have been given by Webb[2]. This need for high overall efficiency in infinitely variable gears makes me wonder whether mechanical arrangements, which would give a high efficiency but would necessarily include torque ripples in their output, have not been too lightly dismissed. The internal combustion engine, after all, has such torque ripples in its output, and these can be adequately smoothed out in the majority of cases.

The first two-pedal control arrangement of which I had experience was on the experimental 2½ litre Lagonda, which had a Newton centrifugal clutch and a Cotal gearbox[3]. An interesting problem on the latter was getting smooth changes ; this depended upon the take-up characteristics of the electromagnetic clutches. A fairly soft steel had to be used for these, to avoid too much residual magnetism. Because of the uncertainty about effective air gap at the engaging surfaces a margin of attracting force had been left in working out the ampere turns of the coils. Since this effective air gap proved to be less than the textbooks had suggested, we thought we might improve the wear characteristics of the faces by hard chromium plating, and at the same time improve the smoothness of gear changes, by reducing the torque capacity of the clutches ; so far as the magnetic circuit is concerned, chromium plate is equivalent to air. We found that the increase in smoothness of change was far more than would be expected from the change in torque capacity alone. The most likely explanation of this seems to be that with the original arrangement the rate of increase of attraction, and hence of frictional force, is extremely rapid over the final stage of approach of the plates. This would give a grabbing tendency. The chromium plating, by introducing extra air gap, considerably reduced this rate of increase of attraction on final engagement.

Chromium plating, however, is expensive and the next idea was to get the same effect by relieving the faces on the part of the clutch plate closer to the axis than the gap into which the coils fitted. This would permit the maximum effective radius for the clutch surfaces, and should give the same effect. Development unfortunately did not proceed far enough for us to discover whether such an arrangement would maintain the desired characteristics, as wear of the engaging surfaces took place, the rate of wear being uncertain (Fig. 3).

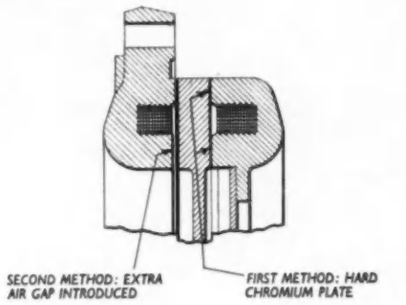

Fig. 3—Methods of improving gear change : Cotal gearbox magnets.

With the chromium plating on the surfaces, gear changes were extremely smooth. One of the difficult changes was that from third to second and vice versa, since in this change both the clutch keeper plates had to move from one magnet to another, and the order of disengagement and re-engagement was haphazard as between the two. I wonder now whether it might have been possible to attain at least consistency by phasing these by the switching arrangements.

Disposition of Mechanical Units

In the car as a whole there is the structural problem of obtaining sufficient rigidity and avoiding undesired resonances in various parts. This is too much an individual problem to be capable of general discussion. The behaviour of the car in the widest sense, however, does depend on the disposition of the mechanical units, and present tendencies with regard to these are interesting.

The larger private cars seem likely to retain the front engine and rear drive layout ; it seems certain that independent suspension all round will spread. The gearbox or transmission can then be at the rear of the car, away from the front floor-boards where it is a nuisance. It can go under or even behind the rear seat. The propeller shaft runs at engine speed and has, therefore, a higher mean speed, but can have a lower torque capacity.

In the smaller sizes of private car, the present trend, which puts the engine at the same end of the car as the drive, seems bound to continue and become a practically universal arrangement. Ker Wilson[4] has indicated that for a conventional transmission the natural frequency of the connection between engine and rear wheels is low enough for resonance effects to lie outside the running range. With engine, gearbox and

final drive forming one unit, connected to the wheels by comparatively rigid shafts, it is unlikely that the mounting of the complete unit can be soft enough to maintain the engine-drive wheel torsional frequency low enough, so that extra torsional flexibility will be required. Developing the means to provide it at a reasonable cost is one of my present problems.

The trend, on this side of the Atlantic, towards a smaller overall vehicle size for a given capacity of passengers and luggage helps considerably from the overall stiffness aspect.

Very worth-while reductions in engine as well as overall size become possible as a result of the present trends when thinking in terms of a given passenger and luggage capacity and performance.

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[2] Webb, C. R., 1952–53, *Proc. Auto. Div. Instn. Mech. Engrs.*, Part III, page 104, "The Effect of Gradient on Fuel Consumption and Speed of a Road Vehicle."

[3] Shorter, L. J., 1937–38, *Proc. Instn. Auto. Engrs.*, Vol. 32, page 337, "Transmission Gear Developments."

[4] Wilson, W. Ker, 1935–36, *Proc. Instn. Auto. Engrs.*, Vol. 30, page 453, "Torsional Vibration in Engine Crankshafts."

Earls Court Motor Show

No. I

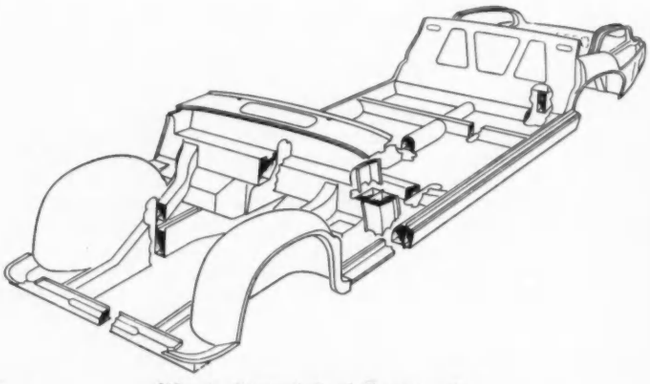
The 1961 International Motor Exhibition was the occasion for the first appearance of a new saloon car designed to combine comfort with high performance and embodying independent wheel suspension.

THE forty-sixth International Motor Exhibition of the Society of Motor Manufacturers and Traders Ltd., opened last Wednesday and continues until Saturday next week. The character of these annual exhibitions will be familiar to our readers, and this year's display is distinguished only by a distinct reduction in the variety of the products shown by native manufacturers; for example, rear-mounted engines, direct air cooling, and dynamotor starting have joined constant-height suspension in being peculiar to foreign cars. The exhibits have, of course, changed since the previous show, and particularly noteworthy is a general increase of wheelbase among all but the smallest models in the British Motor Corporation range, together with, in the case of the "B" series models, an increase in track to afford more room in the rear seats; these modifications have been effected without alteringthe basic pressings of the structure, and in fact in some cases the long wheelbase cars are shorter overall. Additionally, a number of cars new in name have been evolved on the basis of familiar designs.

The Jaguar Mark X resembles the grand touring "E" type in having the "S" engine, independent suspension and integral construction. There are four hooded headlights, of which the inner pair are mounted on the forward-opening bonnet

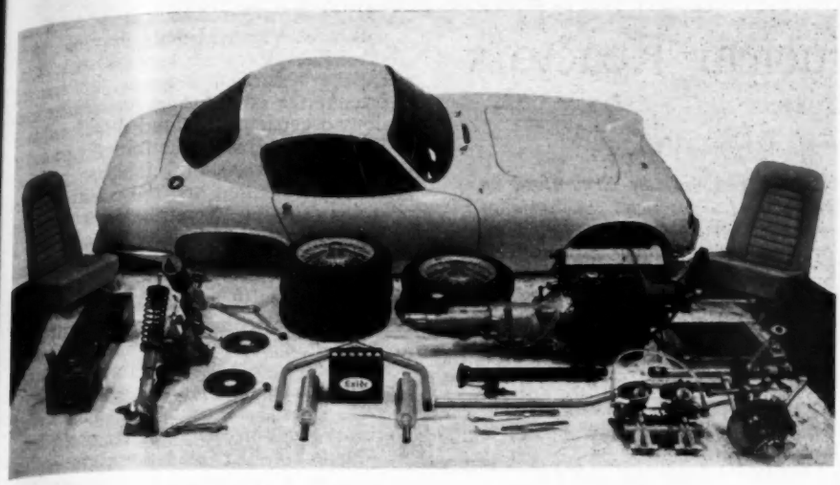
Outstanding, however, is an example of a basically new car which has not had its identity distinguished by a unique designation, the Jaguar Mark X saloon. This vehicle has a twin camshaft six cylinder engine derived from those of the Marks VII, VIII and IX, but there is independent rear suspension like that of the "E" type coupé and an integral body-chassis structure conceived on similar lines to that of the grand touring car (see page 42, March 17, 1961). The new saloon is slightly shorter in wheelbase and longer overall than the old, but the major difference is in height, which has been reduced substantially. Both the shape of the envelope and the disposition of the load-bearing elements can be perceived in the accompanying illustrations; it is pointed out that the roof is not heavily loaded so that the windscreen pillars can be kept narrow, and it may be surmised that a drop-head version of this model too would be feasible. While the configuration of the body is essentially as on previous models, it has been refined; detachable wheel covers are no longer needed, the whole complement of lights and horns is built in, and the bonnet, complete with air intake and the two smaller headlights, now opens forward.

While the load-carrying structure is similar in concept to that of the "E" type, the saloon displays certain interesting differences. It will be recalled that on the coupé the entire final drive and rear suspension is a subassembly attached to the structure by rubber-mountings; in the saloon this is true also of the ball-jointed front suspension, and hence the familiar long torsion bars have been replaced by coil springs. The increased wheelbase and weight are overcome by power assistance for the recirculating ball steering gear. A major change is that a greatly increased range is afforded by a pair of 20-gallon fuel tanks, one, complete with filler and submerged electric pump, in each rear wing—this is expected to allow 320–400 miles to be run without refuelling. Unlike the grand touring car, the saloon is available with an automatic transmission, the well-known Borg-Warner as used on the earlier models, and a small difference is the use of a foot dipswitch—the controls, mainly tumbler



(Above)—Jaguar body shell construction

Right)—Interior of the saloon, showing the broad sills forming the strength members. The rake of the backs of the front seats is adjustable: hence the inclination of the unfolded table. The sloping surface at the front of the table is a mirror



The Lotus "Elite" coupe is available in the form of components, as seen here

switches working up and down, are otherwise similar, with the addition of a fuel pump selector switch.

The new saloon has very elaborate equipment, including a heating and ventilating system controlled by push-buttons; the water valves, heater flaps and air intake vents are actuated by vacuum servos. Large quantities of air can be delivered to ports which are adjustable to direct them where desired in both the front and the back of the car.

Another among the minority of the exhibits which employ independent suspension, the Lotus "Elite," appeared this year in the form of a kit of components to be assembled by the purchaser; supply in this form has previously been the practice for a number of cars that are little more than assemblies of parts manufactured by other makers for other models, but this is probably the first time that a car designed, with very little compromise, for high performance has been marketed in this form. As the accompanying illustration suggests, the fact that the "Elite" is of integral construction means that only straightforward assembly operations are left to be done by the purchaser; there are no large and relatively flimsy body parts to be emplaced.

The exhibition was the occasion of the first public appearance of a sports or *gran turismo* car introduced by the Reliant Engineering Company (Tamworth) Ltd., and named the "Sabre." The appearance of the car is familiar, since it has an Ashley Laminates body with the headlights exposed. The chassis also is familiar, resembling the "B" chassis of L.M.B. Components Ltd. (see page 62, January 8, 1960, and page 609, April 14, 1961) but with significant deviations. While the box members are still formed of two channels united by seam welding, the webs are no longer stabilised by flanged holes. The transverse leaf spring that introduced roll stiffness into the front suspension has been replaced by a pair of coil springs enclosing telescopic shock absorbers. The rear axle is still located by four links, but one link each side now runs in and back instead of in and forwards; thus there are in effect Watt's linkages at both ends of the axle, and it would appear that the roll stiffness varies in magnitude (and the torsional stress in the live axle in sign) with the extension of the rear springs. The "Sabre" has a Ford "Consul" engine, but with a motor-driven cooling fan, and a ZF gearbox with four close ratios (first is 2·53 : 1) having synchromesh.

(To be continued)

Letters to the Editor

CLEAN AIR FOR CITY STREETS

SIR,—The letter from R. D. Reynolds is constructive (THE ENGINEER, September 22, 1961, page 474) reminding us of fumeless and practically noiseless electric vehicles, which can undoubtedly help to keep the air of our city streets clean; free from oily fumes. Almost every day one reads in the Press of disgust, annoyance, and serious alarm at road vehicle exhaust fumes. Engineers may therefore be moved to advocate systems of exhaust gas treatment that have not previously been used. If so they should, in some cases, deserve to be quickly tested in practice by people who are themselves hopeful of preventing this growing public nuisance.

Has the Ministry of Transport or the L.T.E. ever tested out, in fact, two types of non-proprietary vertical exhaust systems that appeared novel when they were suggested in THE ENGINEER of August 25, 1961?

T. HENRY TURNER

Derby.
October 12, 1961.

MATERIALS DATA FOR ENGINEERING

SIR,—A new scheme has been devised involving a programme, developed on the Mercury computer, which translates assorted information on all types of engineering materials into standardised data sheets; furthermore materials (if they exist) possessing pre-defined properties may be selected automatically. By the use of this programme, it should be possible to keep designers more efficiently in touch with latest developments.

About 100 properties may be considered by the computer, e.g. strength, thermal conductivity, at seventy different ambient conditions which include temperatures ranging from −270 to 5000 deg. Cent.

For maximum coverage of the materials field material manufacturers and research workers would need to be invited to contribute information on materials, which would be processed on a Mercury digital computer into standardised form.

Literature describing these proposals in greater detail is available, and interested organisations are invited to write stating the range of interests and views on this subject to the Director, Royal Aircraft Establishment, Farnborough, Hants.

P. H. H. BISHOP

Royal Aircraft Establishment,
Farnborough, Hants.
October 10, 1961.

Books just published

Mathematical Programming
310 *pages. Tables. Diagrams.*
Publisher: Addison-Wesley Publishing Co., Inc.
Price 68*s.*
by S. VAJDA, D.Phil.

Designed as a textbook at graduate level, this volume gives an introduction to linear and non-linear programming, with an emphasis on mathematical aspects. The earlier part of the book deals with theoretical foundations, and the latter part considers the expansion of the subject. Chapters include; background history and examples, algebra of linear inequalities, algebra of duality, theory of graphs and combinational theory, general algorithms, special algorithms, uses of duality, selected applications, parametric linear programming, discrete linear programming, stochastic linear programming, non-linear programming and dynamic programming. There is also an appendix on topics of matrix theory required in the book, together with solutions to the set problems, a bibliography and an index.

[Reply Card No. 1229]

Absorption, Distillation and Cooling Towers
477 *pages. Illustrations. Diagrams.*
Publisher: Longmans, Green and Co., Ltd.
Price 70*s.*
by W. S. NORMAN, M.Sc., Ph.D., M.I.Chem.E.

This book is an account of the present-day state of knowledge in design, construction and operation of experimental and industrial equipment. The reader is assumed to have a general knowledge of mathematics, physical chemistry and thermodynamics. Chapters deal with molecular transport problems, mass and heat transfer, multi-component and non-ideal systems, packed towers, liquid distribution and wetting of tower packings, simultaneous heat and mass transfer, pressure drop, bubble-cap and perforated plates, spray towers, and the design of absorption and distillation towers. Each chapter is supplied with references ranging from 1874 to 1960. An index and three appendices complete the volume. These appendices deal with symbols and units, design calculations for the distillation of a multi-component hydrocarbon mixture, and problems.

[Reply Card No. 1232]

Transverse Vibration Theory, Application of Equivalent Systems
301 *pages. Diagrams.*
Publisher: Ronald Press Co., New York.
Price $10.00
By DEMETER G. FERTIS and EDWARD C. ZOBEL

The authors explain in this book their new method of "equivalent systems" which is claimed to cut working time in predicting the effects of transverse vibrations in structural members. This method is developed in the book to the "dynamic hinge" concept, which permits a portion of the structure to be isolated and used to determine the fundamental frequency of the vibration. Chapters included are; principles of mechanics and vibrations, conventional methods, single-span beams of uniform thickness, theory of equivalent systems, multiple-span beams, theory of the dynamic hinge and single- and multi-span beams of variable thickness. Also included are a list of symbols used, problems, a bibliography and an index.

[Reply Card No. 1236]

Lubricants for Nuclear Reactors

By P. E. B. VAILE*

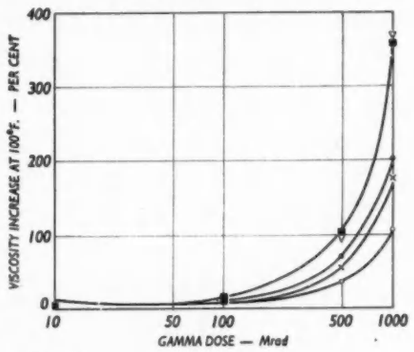
No. II—(*Concluded from page 611, October* 13, 1961)

At a meeting of the Institution of Mechanical Engineers in Chelmsford on September 14, *Mr. P. E. B. Vaile, A.M.I.Mech.E., described the range of operating conditions which lubricants are expected to withstand in nuclear reactors, and particularly in carbon-dioxide-cooled graphite-moderated systems. He discussed requirements proposed by the U.K. Atomic Energy Authority for various applications and described test equipment for evaluating nuclear lubricants. After considering the effect of radiation on lubricants he dealt with the characteristics of some specialised nuclear lubricants and indicated some of the uses of conventional lubricants in reactors.*

Characteristics of Some Speciality Nuclear Lubricants

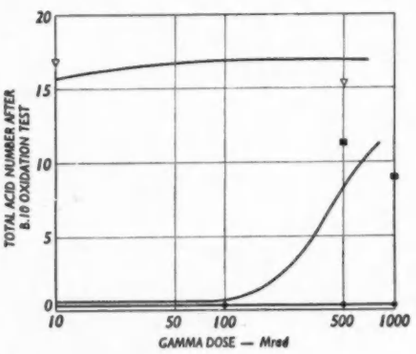
CO_2 Gas Circulator Oils.—The characteristics of a typical product are shown in Appendix I alongside the requirements of this grade. In addition to these requirements, it has been possible, as a result of recently developed additive combinations which are compatible and have satisfactory vapour pressure characteristics, to provide a product with a wider oxidation stability coverage than that specified. This has enabled 1000-hour turbine oil stability tests (IP. 157/56 or A.S.T.M. D.943-54) and satisfactory Socony Mobil B.10 oxidation test results to be achieved.

This product is also capable of withstanding a reasonable degree of irradiation, equivalent to the results shown in Fig. 3 and 4 for the base oil containing conventional anti-oxidants. These results actually refer to a lower viscosity hydraulic fluid (to be referred to later), but the results were otherwise almost identical and do not therefore warrant reproduction.



▽ Base oil.
■ Base oil + conventional oxidation inhibitors.
● Base oil + conventional oxidation inhibitors + anti-rad A.
× Base oil + anti-rad C.
○ Base oil + anti-rads A and C.

Fig. 3—Effect of anti-rads on inhibition of radiation-induced viscosity increase of hydrocarbon hydraulic fluids



▽ Base oil.
■ Base oil + conventional oxidation inhibitors.
● Base oil + conventional oxidation inhibitors + anti-rad A.

Fig. 4—Effect of anti-rads on inhibition of radiation-induced oxidation of hydrocarbon hydraulic fluids

Thus, this product is capable of operation up to a radiation dose of 100 Mrad, unless demulsibility is a critical operational factor, which is unlikely in this application but in which case 10 Mrad would be the safe limit. As previously stated, current radiation levels are much lower than this, but in the event of any future requirements involving high-radiation environments, it should be possible to incorporate anti-rads of the types referred to later, to extend the critical radiation threshold to the region of 500-1000 Mrad, without resorting to the use of expensive synthetic products.

It is convenient to use solvent-extracted high viscosity index base stocks in the formulation of CO_2 gas circulator oils, since they possess lower CO_2 solubility and higher oxidation resistance than other types. It will be recalled that oxidation and corrosion inhibitors are restricted in choice owing to compatibility and vapour pressure requirements, and therefore any contribution that the base oil itself can make with respect to oxidation stability and CO_2 solubility eases the search for suitable inhibitors. It is, however, necessary to use inhibitors since it is is impossible to meet the oxidation and rust requirements of the specification without them. The tendency towards higher operating temperatures is a further reason for the selection of high viscosity index base stocks.

Hydraulic Fluids.—There are already some requirements for hydraulic fluids in components of CO_2-cooled graphite-moderated reactors. In some of these the fluid is completely sealed from the reactor core, and it is possible to use a suitable high-quality conventional inhibited turbine/hydraulic oil.

In the event of possible reactor contamination one line of approach is to develop products on the same lines as the CO_2 gas circulator oil, but containing additionally anti-rads to cater for possible future high radiation levels. Products of this type have been developed, and the results obtained on a low-viscosity hydraulic oil are shown in Figs. 3 and 4.

These results indicate that even certain conventional anti-oxidants (amine type) can retain their effectiveness up to 100 Mrad, but anti-rads can effect significant benefits and offer the possibility of producing relatively cheap hydro-carbon hydraulic fluids capable of withstanding up to approximately 500-1000 Mrad, provided temperatures are not excessive (150 deg. Cent. maximum approximately).

Two basic types of anti-rad can be used, "free radical scavengers" which primarily prevent the formation of unsaturated compounds during the reaction of hydrocarbons undergoing high-energy radiation as previously referred to, and aromatic compounds which, as also previously described, act as shock absorbers or sponges and preferentially absorb high-energy radiation and prevent the cross-linkage or cleavage reactions occurring. Anti-rad A, referred to in Figs. 3 and 4, is of the former type and as expected successfully inhibits radiation-induced oxidation and the acidity and corrosion ensuing therefrom; it does not however prevent viscosity increase since it cannot primarily absorb radiation and prevent cross-linking and polymerisation. However as will be seen from Fig. 3 it can reduce viscosity increase to some extent.

An aromatic type of anti-rad, such as anti-rad C, would therefore be superior with respect to viscosity increase, (Fig. 3) and a product containing both types of anti-rad will provide optimum protection.

None of the oxidation/corrosion tests referred to was carried out in an atmosphere of carbon dioxide, but it is believed that in the case of these oils the operation requirement in carbon dioxide will not restrict the selection of suitable materials as it does in the case of some greases.

If there is no possibility of oxidation occurring in a particular hydraulic system, then suitable aromatic hydrocarbon base oils containing anti-rads are a preferred line of approach, since aromatic base stocks, whilst being less oxidation stable, possess greater thermal and radiation stability than paraffinic (high viscosity index) hydrocarbons. However, it is felt that the use of selected high viscosity index base oils combined with suitable anti-rads may provide a wider overall protection and permit greater scope of application.

It will be recalled that hydrogen is liberated during the reaction of hydrocarbons undergoing high-energy irradiation, and this would occur in the case of the hydraulic and CO_2 gas circulator oils referred to above. It is believed, however, that this would not occur to a significant degree in the above hydraulic and carbon dioxide gas circulator oils until other properties of the oils were seriously affected.

When considering the radiation stability of nuclear lubricants, it should always be remembered that in power reactor applications high radiation levels are usually accompanied by high temperatures, and the latter can be just as restrictive as the former. This applies to greases as well as oils.

For future applications in which exceedingly high radiation and temperature levels might be encountered, it is probable that synthetic aromatic fluids will be used. Results on a product of this type are shown in Table I.

Table I—*Properties of a Synthetic Radiation-Resistant Hydraulic Fluid*

(1) Physical properties	
Specific gravity	0·9916
Pour point, deg. Fah.	−5
Flash point, COC, deg. Fah.	285
Fire point, COC, deg. Fah.	350
Boiling range, deg. Fah.	575–650
Colour	Water white
Viscosity at 100 deg. Fah., cS	23·8
Viscosity at 210 deg. Fah., cS	2·92
(2) Performance data	
Effect of irradiation in helium to 1×10^9 rad:	
(*a*) Viscosity increase at 100 deg. Fah., per cent	28
(*b*) Viscosity increase at 210 deg. Fah., per cent	12
(*c*) Gas evolution	Negligible
(*d*) Flash point	No change
Thermal stability after 1000 hours at 600 deg. Fah.	No change in physical properties

It should, however, be remembered that such products will be expensive, and hydraulic equipment should if possible be designed so that only small quantities of product are required.

Greases: (1) *U.K.A.E.A. Schedule 1 Product.*—Typical characteristics of an

* Mobil Oil Company Ltd., Technical Services Department, Coryton, Stanford-le-Hope, Essex.

approved product are shown in Appendix II against the requirements for this grade. As mentioned previously it is not possible to meet these requirements by the use of conventional soap thickeners, although suitable hydrocarbon base fluids may be employed, and the particular product referred to is a modified clay-thickened hydrocarbon oil using specially selected inhibitors and dispersants.

This product can in fact be used in applications considerably more severe than control rod mechanisms, and Figs. 2 and 5 show that it can withstand radiation levels in excess of Schedule 1 requirements.

(2) *General Purpose Greases.*—Since these greases are intended for wide application in such reactor components as fuelling and ancillary machines, high temperatures and radiation levels must be catered for. Thus although a good Schedule 1 product, such as that referred to above, can be used in some less severe general purpose applications, the use of hydrocarbon-base fluids over extended periods is no longer possible when temperatures greatly exceed 150 deg. Cent., such as the 200 deg. Cent. level specified in Schedule 2.

One method of overcoming high-temperature problems is to employ silicone-base

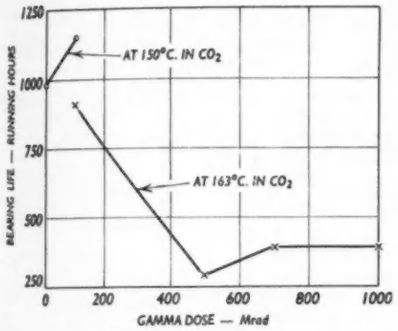
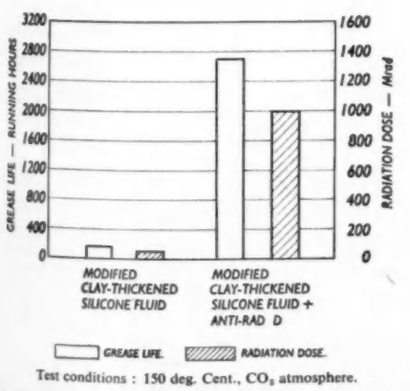


Fig. 5—Effect of radiation on performance of approved U.K.A.E.A. Schedule 1 grease in modified Annapolis bearing rig test

fluids. These are not generally as radiation stable as hydrocarbons, but they vary considerably in radiation stability and volatility, and by judicious selection and the addition of suitable anti-rads it is possible to produce a base fluid for a grease which possesses high-temperature stability with a good degree of radiation resistance. Suitable anti-rads will at the same time protect the thickener and prevent thickener breakdown.[8]

The addition of anti-rad B greatly increases the bearing rig life. The beneficial effect of anti-rads in greases has been confirmed under dynamic irradiation conditions in the



Test conditions : 150 deg. Cent., CO_2 atmosphere.

Fig. 6—Effect of an anti-rad on the performance of a grease under dynamic irradiation conditions in the "Setra" rig

TABLE II—*Performance of Synthetic Speciality Nuclear Greases in the I.P. Bearing Rig*

Type of grease	Temperature, deg. Cent.	Radiation dose prior to test, Mrad	Bearing life, running hours	Comments
Calcium complex soap thickened polyalkylphenylether	175	0	524+	Test discontinued, bearing and grease satisfactory at end of 425 hours.
	175	100	471	
	175	300	251	
	175	500	208	
	175	700	167	
Pigment thickened polyphenyl-ether	175	0	500+	Test discontinued, bearing and grease satisfactory at end of 500 hours.
	200	0	500	Satisfactory result after 500 hours at 200 deg. Cent., test continued for further 40 hours at 240 deg. Cent. before failure.
	240		plus 40 Total 540	

"Setra" rig (Fig. 6). It may therefore be possible to produce greases meeting the Schedule 2 performance requirements by the use of anti-rads in conjunction with base fluids and thickeners which would not by themselves satisfy the high temperature and radiation levels specified.

An alternative course is to employ synthetic aromatic base fluids (which have high thermal and radiation resistance) combined with special thickeners, and work is being carried out in this direction. Table II illustrates some of the promising results which have been obtained with greases of this type. However, synthetic aromatics, such as polyphenyl ethers, are likely to be expensive, although this may not be too important in view of the small quantities involved.

In some applications where loadings may be heavier than normal, such as on gears, it may be considered advisable to incorporate graphite in a grease. Fig. 7 illustrates how the incorporation of graphite can effect the radiation stability of a grease ; in this particular case the result was beneficial. This demonstrates the necessity for investigating thoroughly the effects of any changes or additions made to a grease, particularly with respect to its radiation stability.

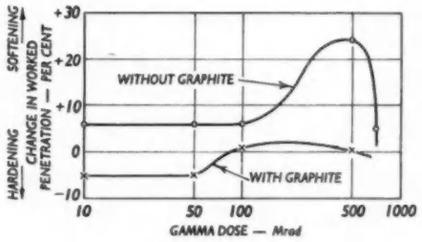


Fig. 7—Effect of graphite addition on the radiation-resistant characteristics of a grease

The use of shields or seals for anti-friction bearings is strongly recommended, since these can increase grease life considerably in addition to minimising any leakage tendency.

Despite the continuing advances being made in nuclear grease technology, it must be remembered that radiation and temperature levels will tend to increase in the more advanced types of reactor (such as the advanced gas-cooled reactor), and there will remain areas where lubricants cannot be used.

Use of Conventional Lubricants

For reasons of economy and simplification, conventional products should be used wherever possible. In some reactor designs there are areas where radiation is present but the lubricant is completely sealed from the reactor core and hence there are no compatibility problems. In such instances it is possible to utilise conventional lubricants, provided radiation and temperature levels are not too severe; therefore the effect of radiation on some conventional lubricants has been determined.

Turbine Oils.—A suitable high-quality inhibited turbine oil is capable of withstanding a surprisingly high degree of irradiation before its performance characteristics deteriorate and, furthermore, it is more radiation resistant than the other conventional products itemised below. From Fig. 1 [ante], it will be observed that the oxidation and viscosity characteristics of the turbine oil do not deteriorate significantly until a dosage of at least 100 Mrad is reached and [from test results given in the paper] this also applies to other characteristics such as corrosion, wear, and load-carrying properties. It is interesting to note that the wear and load-carrying characteristics of this product were slightly improved by irradiation. This effect has been reported elsewhere.[6]

As in the case of the speciality hydraulic fluids referred to above, it will be observed that demulsibility deteriorates at a radiation dose of 10 Mrad, but once again this may not be significant in practice, particularly if the turbine oil is used in hydraulic applications where insignificant quantities of water are present.

As expected hydrogen was liberated during irradiation, but this would not occur to a significant extent until other properties of the product were seriously affected.

It is perhaps of interest to note that the particular turbine oil referred to comprises a high viscosity index solvent-extracted base oil containing conventional oxidation inhibitors, and also a rust inhibitor and a defoamant. The base oil is rather less resistant to radiation than highly aromatic oils but has the advantage of maintaining high oxidation resistance up to a reasonable degree of irradiation.

This it would appear possible to use suitable turbine oils up to total radiation doses in the region of 10–100 Mrad in some instances, and it may be possible to extend this, if necessary, to the region of 500–1000 Mrad, by the use of anti-rads of the types mentioned previously.

Non-Petroleum Base Fire-Resistant Hydraulic Fluids : (1) *All Synthetic Base Type.*—Samples of this type of product, comprising a mixture of chlorinated di-phenyls and alkyl aryl phosphates, developed significant acidity and showed viscosity changes after irradiation to 69 Mrad ; at higher levels of irradiation this became even more pronounced indicating complete breakdown of the fluid. These products were not irradiated below 69 Mrad and therefore a precise "break point" cannot be given in their radiation resistance, but it is probably true to say that they would be unsatisfactory for operation after irradiation to approximately 10 Mrad.

(2) *Water Base Fluids.*—The products referred to here are of the polyalkylene glycol type. When subjected to radiation they show an initial decrease in viscosity followed by an increase [as shown in the paper]. The reason for the initial decrease in viscosity is cleavage of the polymer molycules ; with further irradiation repolymerisation occurs by cross-linking of the fragments with a consequent increase in viscosity. Only slight changes occurred in the total base number (T.B.N.)

of these fluids. Again it is considered that these products would probably be unsatisfactory for operation after irradiation to approximately 10 Mrad.

Products Containing Viscosity-Index Improvers.—Irradiated oils which contain viscosity-index improvers give the best illustrations of cleavage reactions. The effectiveness of the viscosity index of typical automotive and hydraulic fluids is lost at radiation doses of 69 Mrad, and it is probable that these products would be unsatisfactory for operation above 10 Mrad.

All these products evolved gas. In the case of the automatic transmission fluid the gas was hydrogen sulphide, which probably originated from the sulphurised fatty oil additive included in the oil.

Products Containing Extreme-Pressure (E.P.) Additives.—It would appear that E.P. additives in hydrocarbon oils are very unstable when irradiated. In addition to the viscosity and acidity changes [shown in the paper] both the marine E.P. turbine gear oil and the automotive gear oil developed excessive sludge, and in the case of the former oil acidic gases were generated. It is therefore inadvisable to use products containing E.P. additives except at very low radiation levels. This may be of particular interest in the case of marine E.P. turbine gear oils in view of the current interest in marine reactors.

The E.P. additive used in the marine product contained chlorine, phosphorus and sulphur, and the automotive product E.P. additive contained zinc in addition to the above elements.

Greases.—Conventional products of the hydrocarbon mineral oil type, thickened with calcium, sodium, aluminium, lithium, sodium-calcium and lithium-calcium soaps, all suffer from the disadvantage that the soap fibres

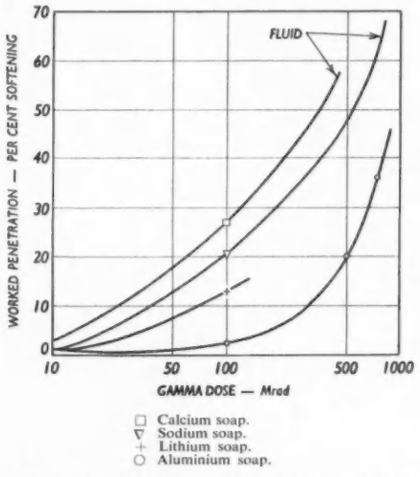


Fig. 8—Effect of radiation on consistency of conventional greases

break down under irradiation, before the hydrocarbon mineral oil thickens and solidifies owing to polymerisation (cross-linking). Thus during irradiation these types of grease will become fluid initially and will subsequently solidify at high radiation levels. In general they will commence softening after irradiation to the region of 10–100 Mrad and will be fluid after 300–700 Mrad. This is illustrated to some extent in Fig. 8 and confirmed by others[1, 5, 6, 7]. It is probably undesirable therefore to use such products where radiation doses exceed 100 Mrad.

Apart from reactor compatibility problems with many of these greases, it should also be explained that soap-based greases tend to react with carbon dioxide to their detriment.

Other Lubrication Aspects

Use of Sintered-Iron Bearings.—In certain instances it is possible to use sintered-iron bearings of suitable purity, and it is advisable to impregnate such bearings with a compatible oil of low vapour pressure. A CO_2 gas circulator oil has been used for this purpose.

Use of Molybdenum Disulphide.—This material has been considered by several of the nuclear construction groups, but it does not appear to be favoured for reactor application, particularly at the higher temperatures and radiation levels where greases and lubricating fluids cannot be used. There is some evidence[9] to suggest that in the presence of CO_2 a 5–10 per cent oxidation of molybdenum disulphide will occur (as shown by X-ray crystallography) at temperatures as low as 100 deg. Cent.

In view of the above it is not considered advantageous to incorporate molybdenum disulphide in speciality nuclear greases for CO_2-cooled reactors. However, in inert helium atmospheres it has been found possible to employ molybdenum disulphide in conjunction with graphite bearings, resulting in improved bearing life. There should, therefore, be no objection to using this material in greases in a helium atmosphere, if considered desirable.

Materials for Dry Running.—Considerable research has been carried out by the nuclear construction groups on dry running in both CO_2 and air atmospheres, for those applications at very high temperature and radiation levels which preclude the use of lubricants. In the case of anti-friction bearings it has been shown [10, 11] that in many applications hard steel is preferable to stainless steel, in fact the harder the better, and in addition hardened steel cages are desirable. Wear and friction are lower at 400 deg. Cent. than at room temperature, owing to the protective effects of metal oxides which are formed more freely at higher temperatures; however attention must be paid to the adequate disposal of this oxidised debris.

In a helium atmosphere, however, protective metal oxide films are not formed, and the customary E.N.31 steel (1 per cent carbon-chromium) bearings get torn with dry lubrication, and it is necessary to use expensive high-speed tool steel (18 per cent tungsten, 4 per cent chromium, 1 per cent vanadium) bearings. By using speciality nuclear greases, however, it is possible to employ the less costly E.N.31 steel bearings.

In other applications graphite journal bearings are being used. A suitable massive graphite can be used [10, 11] in dry CO_2, either against itself or against nitrided steel, but its performance cannot be maintained in dry air or nitrogen.

Conclusions

During the past few years detailed information has been released on the current and anticipated operating conditions of nuclear reactors, and this information together with the availability of suitable irradiation facilities and lubricant test rigs designed to simulate reactor operating conditions have made it possible to produce speciality nuclear lubricants which will withstand some of the operating conditions.

Arising from this, equipment manufacturers have been able to incorporate established methods of lubrication in many of their designs, and it is anticipated that designers will make greater use of this advantage in the future.

There is still scope for producing speciality nuclear lubricants which will withstand higher temperature and radiation levels than current products, but equally design trends indicate more severe operating conditions in the future. Thus there will still be conditions which necessitate dry running of moving parts in some reactors, although this will be minimised.

Appendix I.

Summary of U.K.A.E.A.'s Gas Circulator Oil Requirements, Showing Typical Results on Approved Product

Test	U.K.A.E.A. requirement	Typical results on approved product
(1) BSS 489 : 1955 Medium Grade Tests :		
(*a*) Viscosity at 100 deg. Fah. cs	43/60	56·6
(*b*) Viscosity at 210 deg. Fah. cs	5·5 min.	7·37
(*c*) Viscosity index	—	99
(*d*) Inorganic acidity, mg KOH/gm	Nil	Nil
(*e*) Closed flash point, deg. Fah.	330 min.	485
(*f*) Demulsification number ...	300 max.	195
(*g*) Corrosive sulphur	Nil	Nil
(*h*) Rusting	Absent	Absent
(*i*) Acidity after oxidation test (IP.114/56T), mg KOH/gm	0·2 max.	0·1
(*j*) Pour point, deg. Fah.... ...	+20 max.	10
(2) Vapour pressure at 140 deg. Fah. mm of mercury	$8 \cdot 0 \times 10^{-4}$	$6 \cdot 4 \times 10^{-4}$
(3) Carbon dioxide solubility at 25 deg. Cent. and 1 atm., cm^3 CO_2/cm^3 oil	1·0 max.	0·79
(4) Metals present	State metals and percentage	None
(5) Sulphur content, per cent weight	Report	0·2

Appendix II.

Summary of U.K.A.E.A.'s Schedule 1 Grease Requirements for Control Rod Mechanisms, Showing Typical Results for an Approved Product

Test	U.K.A.E.A. requirement	Typical results on approved product
(1) Drop point (IP. 132/57) :		
(*a*) Before irradiation	200 deg. Cent. min.	>230 deg. Cent.
(*b*) After irradiation to 5×10^8 rad	200 deg. Cent. min.	>230 deg. Cent.
(2) Worked penetration (IP. 50/56):		
(*a*) Before irradiation	220·230	265
(*b*) After irradiation to 5×10^8 rad	220·230	269
(3) Loss by evaporation (A.S.T.M. D.972/51T modified) : CO_2 at 150 deg. Cent. is used in place of air for 400 hours ..	4 per cent weight max.	3·4
(4) Bearing rig test : 20mm bore shielded ball bearing, 100 r.p.m., CO_2 at 150 deg. Cent. and 200 lb per square inch and flow of 10 litres per hour, 720 hours' duration. Grease irradiated to 5×10^8 rad prior to test		
(*a*) Bearing rotation at end of test	Free	Free
(*b*) Signs of fluid or solids at end of test	None	None
(5) Compatibility : Sample of cleaned fuel element canning material coated with grease, exposed to static CO_2 at atmospheric pressure and 500 deg. Cent. for 500 hours. First hour of test with flow of CO_2 of 2 litres per minute ...	No signs of reaction	No reaction

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THE ENGINEER

REVIEW OF BOOKS

OCTOBER, 1961

AUTOMATIC AND FLUID TRANSMISSIONS

J. G. GILES, B.Sc.(Eng.), M.I.Mech.E., A.M.I.E.E.

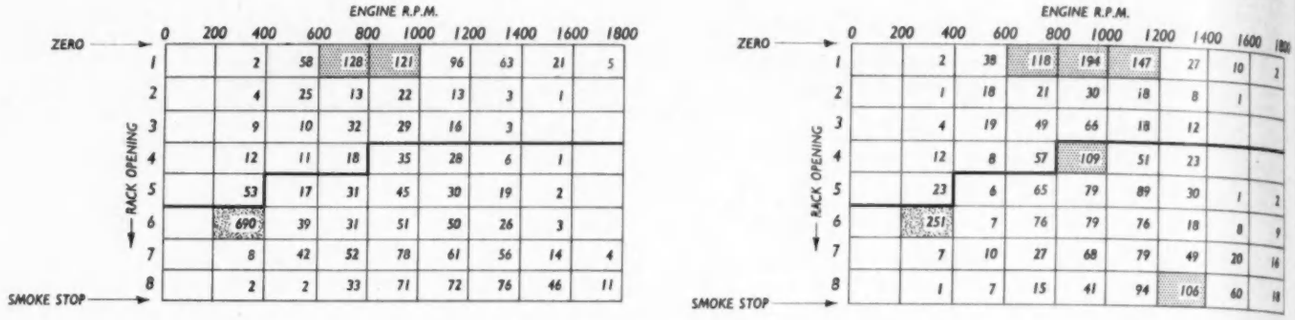
Publisher: Odhams Press Ltd., 96 Long Acre, London, W.C.2. *Price 45s.*

THE overwhelming proportion of modern road vehicles with three wheels or more is arranged to suit drivers, surely a minority, with an odd number of feet! The disadvantages of the separately controlled clutch and multi-speed gearbox are so conspicuous—excessive skill and time needed to start from rest, compromise of ideal performance, frequent operation away from best mode, and difficulty in obtaining adequate engine braking in emergency, supplemented by, in the case of synchromesh gearboxes, the laboriousness of the shifts and the susceptibility of the transmission to abuse—that it is hardly surprising that so much effort has been exerted over so many years to find a reliable and cheap alternative free from such defects. The reason why the mechanism persists is evident; with the buyer's emphasis on initial, rather than running costs, it is easier to sell vehicles that rely upon the rather unpredictable servo mechanism furnished by the operator than those more expensive which are partially or completely foolproof. Three main classes of transmission exist: those in which the relationships between the members are at every instant determined by the driver; at the other extreme, those in which the driver gives only demands, faster/slower and forward/reverse; and intermediately, those in which the driver selects one of a number of more or less complex operating modes for the power unit. The second-mentioned class are customarily termed automatic, and calls for further division into those in which the operating mode of the power unit is inherent, e.g. the "Turbo-Transmitter" of the Invicta "Black Prince"—this subdivision is provocatively close to the first class defined above—and those in which a computer imposes a particular relationship between input and output: this is often a division between transmissions that will adapt few engines to few duties and those that are widely adaptable, since a hydrokinetic converter is highly sensitive to being mismatched with its duties—hence the prominence of automatic-and-fluid transmissions, in which a computer safeguards the converter from dissipating excessive powers. Logic would seem to demand that the intermediate class be divided into those in which the driver merely puts in signals—taking the place of the computer in the last-mentioned subdivision—and those in which the driver does physical work; but so similar is an open-loop power-operated mechanism to a power-assisted one that the sheep and the goats are far more easily distinguished if the division is made between those which will and those which will not change range against the engine torque ("hot," colloquially, and "cold" gearboxes). This entire class is termed by some, including the author of the volume under review, "semi-automatic," although in the case of "hot" boxes simple open-loop servos may be adequate, and it is only if "cold" boxes are used that error-eliminating devices are necessary.

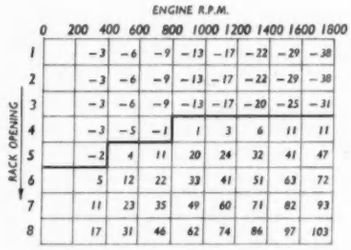
In this treatment the requirements for "gearboxes" in the last two classes are laid down. We refer to "gearboxes" rather than "transmissions" since the requirements make no mention of the need to deliver the power to one or more wheels with at least one degree of freedom relative to the power unit, often at greatly reduced speed, and probably with provision for a plurality of outputs to run at different speeds; this component-oriented approach is sustained throughout most of the text of this book as of others on motor vehicles. Though in his Foreword the author says his book is confined to "mechanisms now available," that phrase is sufficiently liberally treated to permit brief references to a coach with all wheels driven by a Klatte hydraulic system and to the designer's freedom of choice of configuration in the National Institute of Agricultural Engineering experimental tractor. The author does not require that the engine torque-speed characteristic shall be continuous across the zero torque transition, as was suggested by at least some British engineers in the bad old three-pedal days. But he does not lay it down explicitly that it shall not be possible to give inconsistent commands, e.g. with accelerator and shift lever. An attempt is made to develop the requirements quantitively by examining mechanical and aerodynamic losses and the power needed to climb hills, and it is then postulated that the margin needed above the road load should be equivalent to a constant acceleration; this proposal does not even have the merit of simplicity, since in this chapter, in contrast to the remainder, the author plots power instead of torque against output speed. It is at this stage hinted that the transmission should be designed to handle powers far from maximum, but the concept of an optimum operating line is introduced only five pages from the end of the text, and even then it is confused by the implicit assumption that the throttle must move with the accelerator, while no indication is given of how the best possible regime should be evaluated. Descriptions of existing transmissions published by makers, upon whom the author, no doubt, has had to depend, almost invariably show no more than the characteristic for a high, often constant, input torque; how important this mode may be in service can be judged from the accompanying diagrams, which embody the results of one of the few surveys made, in this instance by C.A.V. Ltd., to find out what happens to the fuel of the British road vehicle. (It may be apposite to point out that these results were obtained on a vehicle devoid of automaticity, discounting a fluid coupling to ease the transition to and from standstill, so that they embody a professional driver's choice of where on any equal-power line to work, with a scatter imposed by the facts that ratio changes entail moving selector, accelerator—changes down against the governor were rare—and shift pedal.)

In the descriptive chapters, Mr. Giles has included not only automatic, semi-automatic, and the small number of fluid drives that are neither, but also such gearboxes as the Wilson (Self-Changing) and Getrag "Getromat" (although the irrelevance of the remark that in the latter the "synchronising forces . . . are obviously small," which may surprise those who have attempted to make other than racing changes in a Goggomobil, causes one to wonder whether it was deliberately placed under "Semi-Automatic Transmissions"; such devices as the Ford transmission of the Model "T" are dealt with under "The Development of the Mechanical Gearbox."). That the "cold" gearbox and clutch were not inevitable but chosen is brought out by the inclusion of several pioneer devices, such as the Rieseler transmission of 1927

REVIEW OF BOOKS *(Continued)*



Distribution of operating time of the engine of a bus throughout a run on a route in a city (left) and in the country (right)



Engine horsepower at the centre of each argument of speed and rack opening

which the author describes as almost identical to the 1949 Packard " Ultramatic " (at high speeds Rieseler locked the reaction member to the input to form a fluid coupling, whereas the later transmission has a stator mounted on a free-wheel and a friction clutch between pump and turbine). So widely, if not deeply, is the author's net cast that it is disappointing to find attributed to Major W. G. Wilson only the well-known epicyclic boxes with band brakes ; in the Wilson and Pilcher car the elementary relationship that $2^2=4$ was exploited in the manner embodied in the " Hydromatic " gearbox of forty years later and, moreover, the necessarily different ratios in the two two-speed trains were obtained without using different gear wheels —however, while all forward gears were engaged, by cone clutches, with a single lever, the driver had to remember which of two triggers on the hand grip he needed to squeeze. These brief descriptions of transmissions will probably be the part most frequently consulted by those for whom the book appears to have been written, and it is therefore cause for regret that inaccuracies have crept in. Some diagrams are wrongly labelled, or contradicted by the text ; this happens to both the Brockhouse transmissions illustrated. The familiar Borg-Warner transmission is dealt with twice, once under " Automatic Transmissions for American Cars " and again under " British and European Transmissions," and each description includes a different error in relation to the functioning of the over-run or sprag clutches.

The very fact that so many different transmissions are mentioned in this book should raise the question of how one judges transmissions, but this is an issue that author has—perhaps wisely—chosen not to enter. Nor has he chosen to pay attention to all the practical issues involved : that the Getrag does and the Smiths does not allow starting by towing without benefit of a battery, that a combination of a " cold " gearbox and an automatic clutch, as in " Newtondrive," demands that the engine speed be held up even in upward changes, that Borg-Warner transmissions are always set to change up at less than peak power speed in order to shelter the engine. The final words of the book read: " If this work . . . is of some assistance to engineers and designers making . . . a selection, it will have served its purpose." Despite our criticisms we think it will be.

[Reply Card No. 1273]

ENGINEERING MECHANICS

Statics/Dynamics

IRVING H. SHAMES

Publishers : Prentice-Hall International Inc., 28, *Welbeck Street, London, W.*1.

Statics 30*s*. *Dynamics* 35*s*.

THESE two books are in effect one book in two volumes, *Statics* being covered in Chapters 1 to 10 in the first ; *Dynamics*, in Chapters 11 to 21 in the second. They constitute a vector treatment of mechanics. The fundamental principles are presented in a general analytical manner. At the same time they are applied to practical problems, not only in the narrow field of mechanics, but to a number of associated subjects which share the same basic concepts.

No prior knowledge of vector algebra or vector calculus is assumed. In Chapter 2 of *Statics*, there is a brief treatment of the elements of vector algebra, which is amplified in the following chapter by a consideration of a number of vector quantities and their properties. In the first part of Chapter 11 of *Dynamics*, there is a similarly brief treatment of differentiation and integration of a vector. There is also some introductory treatment of tensors. The concept is introduced in its application to stresses in the chapter in *Statics* entitled " Introduction to Continuum Mechanics," that is, strength of materials and fluid mechanics. The inertia tensor is given a fuller treatment in *Dynamics*, where tensor notation and some properties of tensors are explained.. It is the transformation property which is emphasised ; it is shown how the stress terms and the inertia terms both transform in the same manner.

The first chapter in *Statics* on fundamentals of mechanics provides a general introduction. It reviews the basic laws of mechanics, and considers units and dimensions. Some readers may for the first time meet the " slug," which is the American unit of mass. The author has, whenever possible, adopted the policy of treating the general case at the outset, with the more simple systems treated as special cases. This is in contrast to the normal practice of starting with the simple, and building up to the general. It has been applied in the two main chapters in *Statics* " Equivalent Force Systems " and " Equations of Equilibrium." A special chapter, " Introduction to Structural Mechanics," is devoted to the practical applications. In three sections it deals with trusses, beams and chains. Most textbooks give both graphical and analytical methods of solving framework and other similar problems. The author states in the preface that no graphical methods have been included, since he considers that the techniques for graphical solutions are easy to acquire and, he adds, are quickly lost if not kept up. Graphical solutions of practical mechanical problems occupy a large part of the curriculum of most engineering courses. It is probably far better that they are dealt with independently rather than as an appendage in a book which concentrates on analytical solutions. It is certainly true that when the engineer leaves the drawing board he soon loses his graphical skill.

There is the usual treatment of friction—sliding friction and rolling friction—in a chapter, " Frictional Forces." Viscous friction is covered in one part of the chapter, on " Introduction to Continuum Mechanics." This introductory chapter starts off with the general treatment of stresses. It includes some fundamental aspects of incompressible and compressible fluids, that is, hydrostatics and aerostatics. To complete the volume on Statics there is a final chapter which is yet another introduction, this time to " Variational Mechanics." It includes a discussion on stability and gives the method of virtual work and the method of minimum potential

energy as alternative ways of solving problems of static equilibrium.

In *Dynamics*, the first chapter, " Elements of Kinematics," gives a thorough vector treatment of what has been termed " the geometry of motion." Fundamental equations are derived for velocity and acceleration expressed in terms of different co-ordinate systems, and account is taken of different frames of reference. Included in this chapter, although a problem of dynamics or kinetics, and not kinematics, is the solution for the forces on a particle having a known motion. This enables consideration to be given to the Coriolis force. The remainder of the book is devoted to dynamics, the relation between motion and the causes of the motion. The first aspect to be considered is rectilinear translation. The motion of a particle and systems of particles are dealt with and the usual treatment of oscillatory motion with damping is included.

The next chapter, " Central-Force Motion," provides the opportunity for considering space mechanics and the motion of satellites. The general case of a satellite launched with a radial as well as a horizontal component of velocity is covered. A useful review of conic sections is included. No mention is, however, made of the pedal equation. Nor are any laws of force considered, other than the inverse square law of gravitation. The next chapter, although entitled " General Motion of a Particle," is confined to two-dimensional mechanics. There is the usual treatment of projectiles. A worthwhile inclusion, not often found in a mechanics textbook, is the general treatment of the motion of a charged body under the influence of electric and magnetic fields. The next two chapters consider, in turn, energy methods and momentum methods, both restricted to particles and systems of particles. It is only after moments of inertia have been covered that the motion of a rigid body can be considered. A very comprehensive treatment is given of the derivation and application of Euler's general equations of motion, followed by a brief chapter on energy considerations for rigid bodies. A full chapter is devoted to an examination of the general motion of a rigid body about a fixed point. The Eulerian angles for specifying the orientation of the axes of the moving body are introduced, and the analysis of the motion is based on Euler's equations. Gyroscopic motion and the motion of spinning tops are covered. The final chapter in *Dynamics* reverts to fluid mechanics and is a continuation of the chapter on that subject in *Statics*. It applies the momentum equations, previously limited to a rigid body, to a deformable medium introducing the concept of continuity. The technique of a " control volume " is introduced and applied to the solution of flow problems.

Both volumes have been written in the same style and produced to the same high standard. Chapters begin with an introduction which reviews the subject to be covered and puts it into perspective. At the end of a chapter, or part of a chapter, there is a summary which fulfils the same function in arrears. Each new principle is illustrated by fully worked examples. There is a liberal supply of problems at the end of each chapter, with answers at the end of each volume. The diagrams, particularly the three-dimensional ones, deserve special mention for their clarity. The symbols and the nomenclature should present no difficulty. The vector quantities in bold type stand out clearly. One minor point of criticism is that the single dots on the angles ϕ and ψ, to indicate differentiation, do not show up sufficiently well, since the dot tends to merge with the central line of the Greek letter. A good idea is the adoption of the symbol $\hat{r}$ for the unit vector in the radial direction. It is a pity that this idea is not extended to the other unit vectors to avoid the use of suffixes, such as ε_t and ε_n.

The author's claim to have written a fundamental and rigorous text is well justified. In spite of the general analytical approach, and in particular the treatment of Euler's equations, it is not a book on advanced mechanics. There is no mention of Hamilton's principle of least action and Lagrange's equations are not included. However, it does represent an excellent introduction to more advanced work. It is also more than this : it provides an introduction to a number of subjects involving mechanics apart from the narrow fields of statics and dynamics. Mechanics is an old established subject of interest to mathematicians and to engineers. In recent years it has been brought to the fore with its application to such subjects as satellites and jets. The advent of a textbook, which includes fundamentals by a modern vector treatment and at the same time new applications, is very much welcomed.

[Reply Card No. 1296]

THE GEOMETRIC DESIGN OF MODERN HIGHWAYS

JOHN HUGH JONES, M.S., M.A.S.C.E.

Publisher : E. and F. N. Spon Ltd. 1961. *Price* 63*s.*

THIS book is based almost entirely on American practice in highway design although the author, very wisely, has made his diagrams conform with the British rule of the road. It does not pretend to be a textbook on traffic engineering and this aspect of highway planning is only introduced when it has a direct bearing on geometical dimensions. For instance, the thirtieth highest volume of traffic flow per hour is mentioned as a criterion for design purposes, but the fallacy of using such a rigid rule for universal application is shown by the fact that the eightieth or hundredth highest hourly volumes are also said to be suitable in certain circumstances. The British practice of assuming that peak flows approximate to one-tenth of the sixteen-hour flow appears to agree fairly well with American observations on rural inter-city highways.

One could wish that more space had been devoted to the setting out of curves. The spiral, rightly enough, is suggested as a suitable form of transition and the author bases the determination of transition length on a modified form of Shortt's theory relating to the rate of gain of radial acceleration, introduced in British railway practice as far back as 1908 and still widely used. While agreeing with the author that long transitions should be avoided and that a wholly transitional curve can, indeed, be a dangerous snare on a high speed road, it must be remembered that the limiting longitudinal gradient at which superelevation is applied often proves to be the decisive factor in settling transition length. A gradient of 1 in 200 is regarded as satisfactory in British practice, in which case some of the recommended lengths given by the author in Table 2, 3 would be rather too short if full superelevation were applied to a 30ft carriageway. The statement that the values of " p " in the above table approximate to the shift as normally calculated for a spiral curve does not appear to be applicable in every case, some of the tabulated figures differing considerably from those derived from the standard formulae such as that given in Barnett's well known handbook.

The methods given for calculating the lengths of vertical curves to give adequate visibility over a summit follow accepted practice and the assumption that the height of an obstacle in the line of sight is 4in instead of zero is legitimate and makes an appreci- difference to the lengths required. The author's graphs correlating gradients and vehicle performance confirm the opinion that 1 in 30, commonly specified as the ruling gradient for motorways, is not ideal for the heaviest loads except on very short inclines.

An interesting chapter covers the cross-sectional design of roads, with special reference to motorways, and the difference between American and British conditions is at once apparent when it is realised that some of the motorways in the United States with dual four-lane carriageways have an overall width of 174ft, or thereabouts, and that centre reservations 40ft wide are recommended to give out-of-control vehicles a chance to stop before entering the opposing carriageway. It is also suggested that there should be a hardened shoulder, 10ft wide, on the outside of the carriageway and another, 8ft wide, adjacent to the centre strip. With the difficulties and costliness of land acquisition in this country, British engineers are faced with the problem of designing motorways to carry the world's highest traffic densities within a width, exclusive of earthworks, of 100ft or less.

There will not be unanimous agreement with the author's recommendation that adverse camber, or cross-fall, on a tangent should be taken out before reaching the tangent point of a curve. Such a procedure may well cause vehicles to drift towards the centre of the carriageway and even on a uni-directional road this divergence in the line of travel may be dangerous. On a road carrying traffic in both directions such a drift defeats the main object of super-elevation.

Experience with the anti-dazzle screens erected on parts of the centre reservation of M1 has shown that a barrier of this kind can cause extensive damage if struck by a vehicle. In the book under review the author describes a prototype design of barrier which has been developed by the California Division of Highways and which, it is claimed, will check a runaway car before it enters the opposing carriageway without causing serious harm to the occupants and without causing a bounce back. It consists of chain-link fencing held by horizontal steel cables attached to " H "-section steel posts.

In an excellent chapter on signposting, road markings and miscellaneous roadside equipment, the author points out the advantages of lower-case lettering, and some of the accompanying photographs of direction signs on American highways, lettered in this

REVIEW OF BOOKS *(Continued)*

style, are certainly examples of outstanding clarity. The author has put forward the novel and very sensible suggestion that, when designing a junction, the possibility of equipping it with clear and unmistakable signs should be a governing factor and that, if necessary, the plan should be modified so that this can be done.

The concluding chapters of the book deal with junction design in considerable detail. The advantages and disadvantages of roundabouts are discussed very fairly and the author quotes a capacity value of 800 vehicles per hour per weaving lane as appropriate for design purposes. An identical figure was arrived at by Professor Royal-Dawson from purely theoretical considerations in 1936, and it still appears to be reasonable. No mention is made, however, of Wardrop's formula for roundabout capacities recently derived from practical tests carried out by the Road Research Laboratory, and found to give reliable results when checked by actual counts. Channelisation is said by the author to be a more popular form of junction than roundabouts for at-grade intersections in the United States and a well-designed channelisation scheme, possibly supplemented by partial signal control, can be very effective in certain circumstances.

Junction designs of several different types are treated very fully, and some interesting photographs are included showing typical examples. One of these is a trumpet junction in Holland which is designed with segregated tracks for cyclists, but no other reference is made to possible methods of accommodating this class of traffic which, no doubt, is negligible on American roads. In some parts of Great Britain, however, it constitutes a difficult problem, but several successful schemes have now been evolved for providing segregation, and therefore safety, for cyclists on general purpose highways.

This book is an important addition to the available literature dealing with the scientific design of roads.

[Reply Card No. 1297]

BOOLEAN ALGEBRA AND ITS APPLICATIONS

J. ELDON WHITESITT

Publishers : Addison-Wesley Publishing Company, 10-15, Chitty Street, London, W.1.

Price 51s.

IN 1854 George Boole published *An Investigation of the Laws of Thought*. He demonstrated how it was possible to reduce the processes of logical reasoning to a type of algebra, which in some ways obeyed the laws of common algebra, but in others was very different. This abstract algebra of logic is called Boolean Algebra. Despite its abstract nature and its mathematical and philosophical interest, it is a subject with far reaching practical applications.

Professor Whitesitt provides an introductory approach to Boolean Algebra by considering in his first chapter its application to the algebra of sets. The particular terminology of this subject and the symbolic notation adopted are explained. The fundamental laws of the algebra of sets, which are shown subsequently to be applicable to all applications of Boolean algebra, are given without proof. The concept of a Venn diagram, giving a graphical illustration, is used to explain and provide some justification for these laws which have been introduced intuitively. In the second chapter a more formal approach is adopted by defining a number of independent postulates and proving a number of fundamental theorems. Proofs are given that Boolean algebra satisfies the laws of the algebra of sets that were given in the first chapter. Great use is made of the concept of *duality*, whereby most of the theorems constitute a dual statement with a single proof.

The second application considered is symbolic logic. The basic concept is a proposition which may be *true* or *false*. Propositions can be combined by *and* or *or*, processes which are termed conjunction and disjunction respectively. It is also necessary to specify two unique propositions : one that is always true and one that is always false. If propositions, and their negations, are denoted by symbols and their two types of combination by mathematical operators, an algebra of propositions results. It is shown that this is a Boolean algebra. The method of representing propositional functions by means of a truth table is explained. The chapter goes on to describe a number of the operations in symbolic logic, such as *material implication* and *material equivalence*, to discuss quantification, which is expressed by *quantifiers*, such as *some*, *all* and *no*, and to consider the validity of arguments.

In marked contrast to its more theoretical application in symbolic logic, Boolean algebra has a very practical application in circuit switching. Circuits which involve two-state devices, that is *open* or *shut*, readily lend themselves to this algebraic treatment. In this case the two Boolean operators, which were equivalent to *and* and *or* in symbolic logic, correspond in the algebra of circuits with two switches in series and parallel respectively. One chapter is devoted to switching algebra. Use is again made of truth tables ; this time to represent the closure properties of circuits. How the switching properties of a given circuit can be expressed as a Boolean function, and the reverse process of finding a circuit which realises a given Boolean function, are explained. The following chapter extends the treatment to relay circuits. This entails consideration of the control circuits which operate the relay, and the question of sequential operation. In spite of these more practical considerations, algebraic processes can be used in the design of relay circuits to carry out given functions. The principles of the method are explained, and a number of examples, which show the varied uses of relay circuits, are worked out to illustrate the procedure. The limitations of Boolean algebra, as well as its uses, in its application to the design of relay circuits are brought out.

A brief chapter is included on the circuits for arithmetic computation. These are the basic circuits that are used in modern computors with their ability to carry out complicated functions at a high speed. An explanation is first of all given of the representation of a number in the binary system. It is possible to carry out all the required arithmetical operations on binary digits by combinations of devices termed *logical circuit elements*. In practice these circuit elements may be obtained by various combinations of electronic components : in theory they can be considered as carrying out different functional operations in Boolean algebra. Four basic logical circuit elements are described with their symbolic notation, and with an example of the electric circuit that could be used for the purpose. The first is the circuit element which produces the *complement*, that is *O* if the input is *1* and conversely. The second and third carry out the logical operations of *and* and *or*. The fourth, *flip-flop*, is a circuit element which changes its two-state output on each successive input. These basic logical circuit elements can be combined together to form additional logical circuit elements which have a number of inputs and outputs. An example is the *accumulator* which performs the function of repeated addition, storing the final result on a *register*. The arithmetic processes of addition, subtraction and multiplication can be carried out by means of circuits made up of various combinations of logical circuit elements. Methods are given for the design of circuits for these purposes. They are examples of the many different methods that are used. This chapter is but an introduction to a subject, which has developed rapidly in the last decade, and on which a great deal of material has been published.

A final chapter gives a brief introduction to probability and provides a link between the theory of probability and the algebra of sets, which was considered in the first chapter. The usual combination and permutation formulae are derived and the binomial distribution for repeated trials is included. There is also mention of conditional probability. A very true remark is made in this chapter, which is so applicable to problems in probability, namely " no rules can be found to replace intelligent thought."

Readers of this book are given every encouragement to clear thinking by the simplicity of the treatment and the clarity of the explanations. No advanced knowledge or proficiency in mathematics is required. Although many new concepts and terms are included, the adoption of a standard notation throughout the book to cover all of the three different applications considered helps considerably anyone who is new to the subject. Interest is maintained both by the style of the writing, and by the types of examples that have been included. Examples with fully worked out solutions are contained throughout each chapter : exercises for the student are at the end of each

chapter. At the end of the book there are answers to a selected number of the problems in these exercises. A short bibliography of references for further reading is given at the end of each chapter. This book provides an excellent introduction, not only to Boolean algebra, but to the many different applications of it, and it will no doubt encourage further reading. It should appeal to a wide range of readers in many fields of engineering, and also to those who wish to keep themselves acquainted with the underlying theory behind modern techniques. It is highly recommended.

[Reply Card No. 1298]

SEMICONDUCTING III-V COMPOUNDS

C. Hilsum and A. C. Rose-Innes

Publishers: Pergamon Press, Headington Hill Hall, Oxford. *Price* 60*s.*

THE importance of the semiconductors selenium, germanium, and silicon is so well known as to require no comment; and the recent revolutionary swing from the thermionic valve to the transistor will have made clear, even to the non-specialist, the need for an extensive investigation of other materials whose properties extend, in some way, those of the three mentioned above.

Se, Ge and Si belong to group IV of the periodic table, and the fact that group III atoms have one valence electron less and group V atoms one valence electron more suggests that associations of group III and group V elements might exhibit those properties which have made the group IV materials so important. In the event it transpires that atoms of group IIIb elements unite with those of group Vb to form crystalline semiconductors which are true chemical compounds having formulae of which InSb is typical.

Although the first of these compounds, InP, was first produced over 50 years ago, and Goldschmidt produced the whole series InSb, GaSb, GaAs, GaP, AlSb, AlAs, AlP and AlN over 30 years ago, it was only in 1952 that Welker suggested the importance of the compounds as semiconductors

The Services Research Laboratory has been a pioneer institution in the investigation of new properties of materials and of their applications. The work of the laboratory in the field of super-conductivity is well known but the present book forms the first, readily accessible, report of their thinking in the field of semiconductors. It must be said, at the outset, that the work makes no concessions to popular exposition, it is written as a research report for the expert, or more properly, for experts in the various branches of chemical and physical science which touch upon the subject. Thus the opening chapter, on crystal structure, assumes that the reader is familiar with the techniques and theories of modern inorganic crystal chemistry, whilst the next section, on band structure, takes one at once into quite modern and sophisticated wave-mechanical theory. These chapters are typical of the remainder of the book: the exposition is excellent and provides the expert reader with large numbers of diagrams and graphs together with detailed references to the source literature of the subject; nowhere, however, do the authors explain the technical terms which they use, neither do they give references to the basic texts in which this information is to be found. Now this monograph technique of writing for specialists is possibly acceptable in a higher degree thesis at a university, but it is of dubious value in a book intended for public consumption. It may be argued that the educated physicist should know the definition of a "K—space" or of "cyclotron resonance" but this appears to be untrue since we asked an assortment of recent physics graduates for definitions with no result; even more surprising was the fact that two physicists, of post-doctoral level and working upon semiconductor applications, were also unable to define the terms.

These remarks are made in a spirit of kindly criticism because the book is an excellent one, packed with information of the greatest importance to workers in the field of semiconductor devices. These investigators, often electrical engineers, should certainly acquaint themselves with the material content of the book, but because of the great amount of background which is assumed, they are likely to become discouraged at the start and thus abandon the book unread. For those who overcome the difficulties, however, the rewards are great. After the introductory account of fundamentals the authors pass to a discussion of impurities and defects where, because the group III–V compounds allow a foreign atom to act either as donor or acceptor or sometimes as both, the prediction of properties leans heavily upon experimental evidence; and thence to an excellent chapter which describes the methods of preparation and purification of the compounds. There is then a long chapter which discusses the electrical properties of the compounds with reference to scattering processes, carrier transport, and, most important, effects of magnetic fields. This is followed by an analysis of the optical and photo-electric effects which occur with particular reference to the antimonides and arsenides of indium and gallium.

The book ends with an account of applications, the wealth of which will surprise many readers. Thus, apart from diodes, transistors and classical photocells, there are accounts of such things as variable capacitance diodes, Hall effect magnetometers, magneto-resistance oscillators, solar batteries and optical filters. In the later chapters the difficulties of "jargon" are not so obtrusive, so that the device-engineer can read with profit and understanding. There is no doubt whatever that this is a most important work both for the logicality of its presentation and for the very large numbers of references to basic literature the production is excellent and; authors and publishers are alike to be congratulated.

[Reply Card No. 1299]

DIFFERENTIAL EQUATIONS FOR ENGINEERS AND SCIENTISTS

C. G. Lambe, B.A., Ph.D., and C. J. Tranter, O.B.E., M.A., D.Sc.

The English Universities Press Ltd. 1961. *Price* 30*s.*

FOR the engineering and science student a good basic grounding in certain branches of mathematics is essential and one such branch is the derivation and solution of differential equations. This book is particularly suitable for the engineer, for the authors, Professor Lambe and Professor Tranter of the Royal Military College of Science at Shrivenham, never lose sight of the physical applications, and an outstanding feature is the large number of worked examples and exercises (complete with answers) which are used to demonstrate the application of the various mathematical techniques to practical problems. The material, which is based on the needs of the engineer and scientist reading for a first degree, is presented clearly and concisely.

The early chapters deal with the solution of first order equations, linear equations with constant coefficients and simultaneous equations. The treatment is such that engineers with no higher qualifications than Higher National Certificate should have little difficulty. The special sections devoted to the vibration equation, theory of structures, electric circuits and servomechanisms are of particular value, although some readers might prefer a little more elaboration, particularly in the last topic.

The chapters covering series solutions, the hypergeometric equation, and special functions such as those of Legendre and Bessel are less easily digested, but this is due more to the nature of the mathematics than to any shortcomings in the text. Partial differential equations are adequately dealt with in relation to practical problems and an important chapter on Integral Transforms is included. As stated by the authors, "comparatively few of the differential equations that arise in physical problems have solutions which can be expressed in terms of known functions. Solutions of linear equations can usually be expressed as infinite series, but even then the work involved in computing the numerical value of the solution for a particular value of the independent variable can be very great and the limited range of convergence of such series often complicates matters. For these reasons graphical and numerical methods of finding solutions are of paramount importance," and a separate chapter is devoted to their consideration. A further chapter deals with the Relaxation method.

Reference is made to the use of digital computers, but a surprising omission from a book which purports to pay due regard to modern developments is any reference to the analogue computer, for this type of computer is used extensively nowadays to study the behaviour of physical systems by simulating and solving the differential equations representing these systems. It is a particularly useful tool for investigations involving non-linear equations, as theoretical methods are often either tedious or completely inadequate. However, considerable attention has been paid in recent years to the development of theoretical and graphical methods for solving non-linear equations and some of these are presented in the final chapter.

The omission referred to does not detract from the true value of this book. The authors have shown a real appreciation of the needs of engineering and science students.

[Reply Card No. 1300]

THE TECHNICAL ILLUSTRATOR

H. Cook, A.R.W.A., F.R.S.A., R.D.S.

Publisher: Chapman and Hall Ltd., 1961. *Price* 35*s.*

IT is clear that many more authors are now being attracted to the ever-widening field of "technical publications" as a subject on which to write. *The Technical Illustrator*, recently published, seeks to fill a possible need for guidance by trainee illustrators during the elementary period of their development—particularly those who are, perhaps, seriously attempting to gain an opening in a studio—or planning to take a course of instruction in this form of art. This is no textbook for the earnest student, but as the author himself says, is "... one to be read, without a conscious feeling of learning, by the interested enthusiast...." A

REVIEW OF BOOKS *(Continued)*

broad, general idea of the various forms of technical illustration can certainly be gleaned from its pages, and this is assisted, to some extent, by the large number of illustrations included (eighty-nine in 115 pages of text); several of these appear, however, to have been drawn somewhat inaccurately or roughly—judging by the printed reproductions—but this may well be due to the fact that they are the work of students.

An assumption has been made that the reader "has a basic knowledge of perspective and trimetric projection" and that he "can draw reasonably well"; in fact, neither of these attainments might be possessed by one who is merely an "interested enthusiast," but such a reader could not fail to find both stimulating and instructive a chapter dealing with basic principles—had this been included.

Proof-checking has, unfortunately, not been carried out with the accuracy that the book deserves: the caption to Fig. 37, page 45, contains a spelling error; the word "axle" should read "axis" in Fig. 39, page 49; "alternate" should read "alternative" in Fig. 42, page 53; and a complete mis-conception of the construction of a wire rope appears in Fig. 55, page 70—a three-strand "plait" having been illustrated.

[Reply Card No. 1301]

AEROFOIL SECTIONS

Friedrich Wilhelm Riegels

Translated from German by D. G. Randall

Publishers: Butterworths 1961.

281 *pp. Illustrations, Diagrams.*

Price 200s.

THE increasing demand for aerodynamic efficiency in the last twenty years has led, amongst other things, to an intensive effort to improve the matching of aerofoil sections to the task to be fulfilled. In this country the work of Lighthill and the Goldstein "school" has laid a substantial basis for our understanding of idealised inviscid flow past aerofoils—as well as of the inverse problem of designing aerofoils to produce pre-selected pressure and velocity distributions. Naturally, the British work has been paralleled by similar work in Germany and it is, in the main, the German contributions which are given in this volume, which surveys the theory and a whole range of experimental data on aerofoil sections. Riegels is obviously well equipped to undertake the preparation of this study, particularly in view of his association with the Max Planck Institut für Strömungsforschung at Göttingen and because of his original contributions of the theory of flow past thick aerofoils.

It is now a matter of common agreement that viscous flow and separations of the airflow from the surface result in discrepancies between test and theory to an extent that purely theoretical estimates are unreliable. This being so, the theory presented will perhaps be of some interest, but only to the few specialists intimately concerned. Most British aerodynamicists will be well content to rely on the various publications already available in this country, and will turn to this new volume mainly for the tabulated data and graphs which occupy over half the book. This is not intended to be derogatory but there would appear to be too little that is new and too little that is not already available in other forms. The two dimensional problem once solved, the three dimensional problem with finite span aerofoils of modern planform is now our main preoccupation. There will be few who will want to go back to study alternative methods of tackling the two dimensional case.

The hardest task facing an author compiling a survey on a fairly confined topic is that of discriminating between what should and what should not be included. The reader who has grown up with this subject will undoubtedly feel quite nostalgic when faced with data on R.A.F., Clark Y, and Joukowski sections. Those of Piercy, Piper and Preston also receive honourable mention, but surely, apart from the issue of completeness, there can be little justification for their inclusion in a modern book. By the same token, one may suspect that much of the Göttingen section data is a relic of a past era.

The tables and graphs in the latter half of the book represent a very mixed bag. The documentation of the graphs tends to be too limited, so that some of the value is lost. However, there is a mine of detailed experimental information here awaiting those who make the effort and browse through the seventy-five odd pages crammed with graphs. The printing is of a consistently high quality so that the graphs are both readable and usable (other publishers and printers please note !).

Mr. Randall's translation of the German text is excellent although a little ponderous at times. The expression "We will now" can be irritating. There do not appear to be many errors—the only one noticed was in the expression for the leading edge radius of an aerofoil where the dimensions are incorrect due to omitting the chord from the equation.

Leaving technical matters aside, the rising cost of living seems to have hit the bookseller. At £10 a copy, the market for any reference volume is certainly going to be very small.

[Reply Card No. 1302]

SERVOMECHANISMS

P. L. Taylor, M.A., A.M.I.E.E.

Publishers: Longmans,

1960. *Price* 42*s.*

THE author, Mr. Taylor, is a Cambridge graduate, who has had experience both in the aeronautical field and in the industrial, automatic electrical control field. He also has spent some time lecturing. This book is written to introduce students to this subject of servomechanisms and assumes that the reader has no previous knowledge of the subject whatsoever. It is aimed at students in the last year of a National Certificate or those who are taking either a Diploma of Technology or a Degree Course.

The book is divided into three parts. Part I is a simple basic background of a subject which is quite comprehensive. There is a chapter on data transmission and another on data computation. This part of the book is purely descriptive and makes virtually no use of mathematics. Part II of the book is the largest portion and is the real justification for it being written. In this portion the author describes the many practical solutions to the concepts developed in Part I. These include not only separate chapters on feedback amplifiers, rotary amplifiers, phase sensitive rectifiers and other basic electrical components, but, quite surprisingly, there is a chapter on hydraulic systems. The author also derives for each component part the equation of motion. However, the mathematics are limited so that only the ability to differentiate or integrate is essential. Part III is concerned with the general theory and analysis of linear closed loop control systems. The first four chapters deal with the theory of linear systems and the next two with the extension of the theory into closed loop working. In this part, full use is made of mathematics.

There is an Appendix which, besides helping with the mathematics entailed in this type of study, also gives problems, and their answers, which are cross-referred to in the various chapters.

The book is well written, well produced and would make a useful investment for many students.

[Reply Card No. 1303]

PRINCIPLES OF SEMICONDUCTORS

M. G. Scroggie, B.Sc., M.I.E.E.

*Publishers: Iliffe Books Ltd., Dorset House, Stamford Street, London, S.E.*1. *Price* 21*s.*

ALL who followed this author in taking their first steps in radio will welcome his return as a guide to semiconductors. The book is a revised version for British consumption of *Fundamentals of Semiconductors* published last year in the U.S.A., and aims at providing readers with the background necessary for understanding more advanced literature and articles. Five chapters deal with physical aspects of the subject, leading to examination of the properties of semiconductors and the behaviour of junctions. All begins disarmingly enough, with simple drawings of milliammeters and dry cells, but some application is required to stay the course. As of yore, the author keeps up a lively and wide-ranging commentary which combines with his gifts of exposition to make the way seem relatively easy. One wonders, however, if those of his readers who need a drawing of a bucket of water being swung in a circle to illustrate centrifugal force will keep up with him in his explanations of basic and equivalent circuits.

The later chapters of the book deal in outline with the numerous and multiplying forms of semiconductor devices, such as surface barrier transistors, mesas, and tunnel diodes. Photocells have a chapter to themselves, and a final chapter on other semiconductor devices covers briefly effects such as those of thermistors and varistors in the electrical field and of superconductivity and masers. This book is an eminently readable introduction to its subject for all whose duty or conscience calls them to keep abreast with what is taking place in the semiconductor field, but have lost the habit of assimilating instruction conveyed in a more pedagogic manner.

[Reply Card No. 1304]

Fifth Anniversary of Calder Hall

The first nuclear power station at Calder Hall was opened by Her Majesty the Queen on October 17, 1956. Five years of operation have been celebrated this week by open days and an exhibition on the site, where to-day the original Calder "A" and later Calder "B" stations (the latter commissioned fully in 1959) have a combined electrical output of 200MW.

SINCE the opening of Calder "A" station five years ago, development by the United Kingdom Atomic Energy Authority at Calder Hall has enabled several improvements on the forecast performance figures to be realised. The designed heat output of 180MW from the four reactors has been raised by stages to 220MW, while the electrical generation now stands at 200MW as compared with the forecast figure of 168MW. Two contributory factors have been an increase in fuel temperature from 408 deg. Cent. to 418 deg. Cent., and operation of the coolant circulating blowers at their maximum output. With regard to optimum temperature conditions, their attainment is assisted by the use of computers to predict the temperature distribution across the reactor and forecast the best absorber pattern.

In 1959–60 the overall load factor of the station was 83·2 per cent, and in 1960–61 this was improved to 88 per cent. Of the remaining 12 per cent, 6·8 per cent was due to recharging the reactors. Great advance has been made in this direction, for whereas the first recharge at Calder Hall took eleven weeks, in the ensuing years successive improvements in the recharge equipment have enabled some 10,000 fuel elements to be replaced in under four weeks. On the most recent occasion the recharge occupied twenty-four days. The limiting factor tends to be the amount of maintenance work which has to be done at the same time.

Excluding recharge time, the 1960–61 figure for load factor was about 95 per cent, approximately half the remaining 5 per cent being accounted for by the experimental programme. No. 4 reactor in that year ran at 96 per cent load factor without a single channel having to be pulled out. Some channels of fuel have been left in for four years giving a highest irradiation of 3900MWd (H)/ton, and an average of 2700MWd(H)/ton. There are 250 elements which have been irradiated to more than 3000MWd(H)/ton, and 750 have exceeded 2000MWd(H)/ton. A complete charge of fuel has been allowed to remain in one reactor for two years.

Only four or five complete failures of fuel elements have been recorded. About 200 fuel elements have developed cavitational failures such that an incipient leak is detected and can be watched for some months before they have to be taken out. This occurs in the cooler end of the reactor, and no problems have been found at the hot end. When a new charge of fuel is loaded into a reactor, the final test is made after the elements are in place. It is assumed that some elements may have small leaks at the welds, and to detect them the pressure is dropped rapidly as soon as the reactor comes up to power. Since adopting this system only one element has developed a rapid failure in the reactor.

Experiments are carried out on the irradiation of steel and graphite, and a machine has been developed which can take specimens of graphite from the channel walls themselves. There is no reason to believe that the reactors will not reach their twenty years of life, and the likelihood of having to carry out a Wigner release is stated to be becoming more and more remote.

Following the use next year of surplus steam from the Calder plants for space heating and process heating at Windscale (THE ENGINEER, July 14, 1961, page 46), it is proposed to shut down the Windscale boiler houses completely. It is estimated that nuclear steam will cost 13s. per ton as compared with the present cost of £1 per ton. Two of the Calder turbines have been re-bladed to raise their output from 23MW to 27MW, and two more will be so dealt with.

The Calder reactors, with their extensive on-core instrumentation, have provided the means of testing fuel elements for the civil nuclear power stations in conditions more stringent than those to which they will be exposed in practice. Improved types of "Magnox" have been tested, and civil elements have been fitted with strain gauges for the collection of data while actually in the core. It is pointed out that the eight reactors, each with nearly 1700 fuel channels, provide great scope for statistical studies.

From experiments so far it is concluded that 4000MWd(H)/ton should be obtained from elements in civil reactors. No trouble from bowing is expected. The tests have shown the need for minor design improvements, and all civil fuel elements now incorporate anti-rattle devices. The effect on elements in the core of temperature changes caused by on-load recharging in their vicinity has also been studied. No trouble has been experienced after heat cycling obtained in a Calder Hall reactor by oscillating control rods up and down for 13,000 cycles adjacent to the elements being investigated.

Calder Hall has provided a useful reserve of electricity supply for the West Cumberland

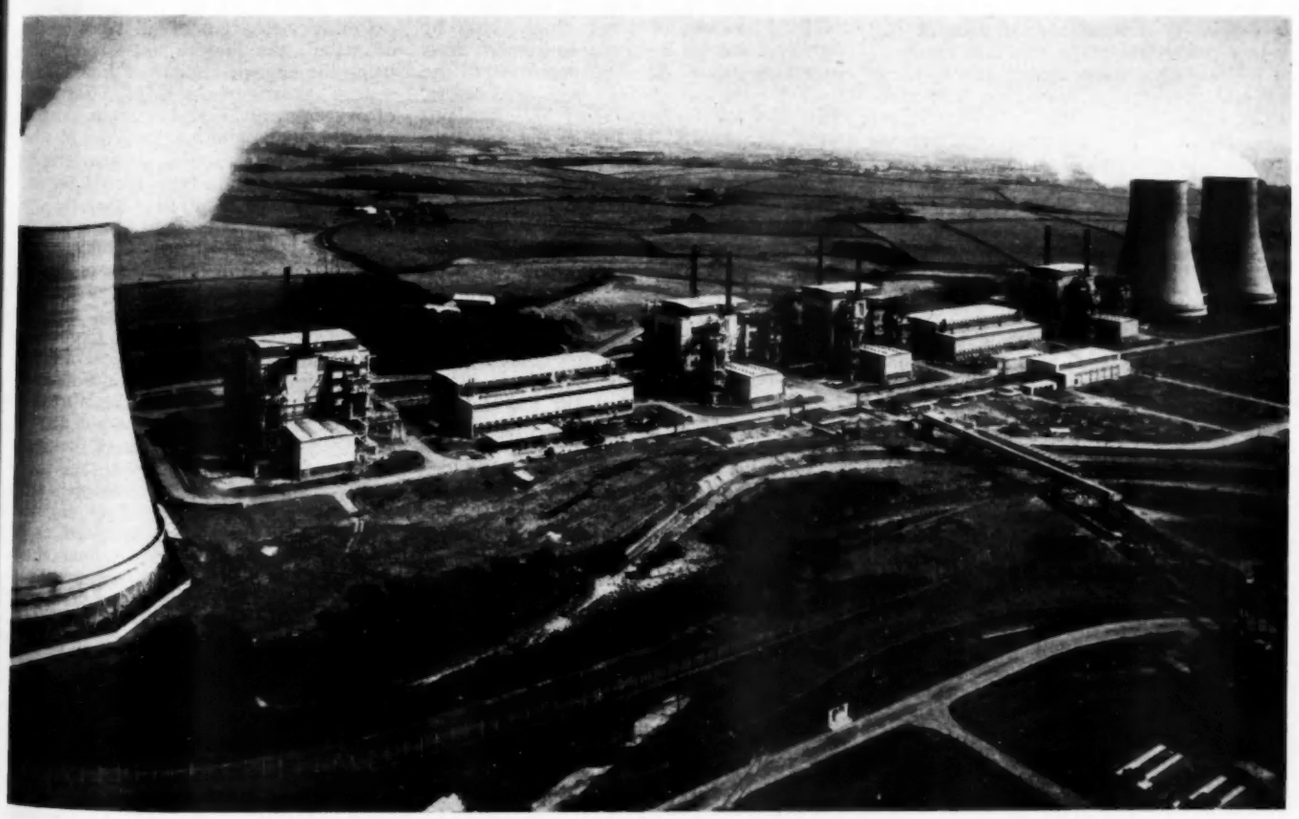


Fig. 1—Calder Hall "A" and "B" stations, each consisting of a central turbine hall and two reactors, with four heat exchangers per reactor

Fig. 2—A basket of fuel elements being loaded into the charge machine

area on an occasion when lightning struck an overhead line. Forecasts of lightning conditions are now received at the station, and preparations are made when necessary to meet an emergency load by preliminary adjustment of the automatic speed control systems of the Ward-Leonard drives to the blowers, so that the speed control characteristic does not cause an overload in abnormal input conditions to the sets.

During a visit to the station in connection with its fifth anniversary, a demonstration was given of the charge and discharge machines in action on a reactor undergoing a fuel change. We illustrate in Fig. 2 a " basket " of fuel elements being loaded into a charge machine. For these operations well-established and simple methods of control have been chosen. The operator regulates the speed of the grab himself during lowering and hoisting, aided by mechanical indicators which show him when the grab is entering the zones where speed must be reduced.

There has been no reason yet to replace the original electronic control and instrumentation systems for the reactors by new semiconductor devices, although semiconductor techniques are used in equipment acquired since the opening, such as a 450 point data logger for one reactor, and a Panellit 609 data processing system. The latter was demonstrated making a heat balance calculation from readings taken in the control room. Closed-circuit television cameras permit inspection of the fuel channels. One instrument carries an electrically-operated grab for retrieving objects which may be obstructing normal charge or discharge operations.

The burst slug detection apparatus and its associated recorders were also inspected, and it was stated that when cavitation failures occur, experience sometimes enables the particular element affected in a channel to be identified by studying the trend of the record. Finally, a demonstration was given on a simulator of a test in which the CO_2 circulation was stopped in a reactor on power and the control rods were prevented from dropping. The fuel temperature thereafter rose by about 120 deg. in 1½ minutes then fell again and was normal after three minutes.

Water Pollution Research

Last week, the Water Pollution Research Laboratory at Stevenage, Herts, which is one of the D.S.I.R establishments, held open days. A new wing of the Laboratory, largely devoted to pilot plant laboratories, has recently been completed. These new facilities, and also the demands which are expected to be made on the Laboratory as a result of new legislation, focus interest on current researches there, some examples of which are briefly described hereunder.

DURING the two-and-a-half years since the Water Pollution Research Laboratory's last open days were held, three Parliamentary Bills increasing control over the disposal of waste waters have become law. These are the Clean Rivers (Estuaries and Tidal Waters) Act, 1960 ; the Rivers (Prevention of Pollution) Act, 1961 ; and the Public Health Act, 1961. This legislation has led to a greater interest in pollution control, and to meet the increased demand by industry, local authorities and River Boards for research on this subject, a new wing of the laboratory has just been opened which will increase its capacity by about 40 per cent. A large part of the new wing consists of pilot-scale laboratories, so that methods of treatment can be developed to a stage where their application to works conditions is straightforward.

Under two of the new Acts, River Boards are given increased responsibilities for controlling the discharge of effluents into all rivers or estuaries in England and Wales, with the exception of the Thames. The Clean Rivers Act gives River Boards the power to decide to what extent effluent or sewage must be purified before discharge ; the Rivers (Prevention of Pollution) Act will eventually bring under control all those concerns not affected by the 1951 Rivers Act. Industry's need to seek advice from the Water Pollution Research Laboratory will, therefore, become even more urgent in the near future.

Because of the increasing demands on available sources of water supply, both by industry and by domestic consumers, it is becoming more and more necessary to use surface waters which have been used before. The work of the Laboratory falls into two main categories ; the first is the investigation of methods of treating polluted liquids prior to their discharge—both to increase the efficiency of existing methods and to develop new ones. The second is the study of surface waters, with the object of determining the effects of pollution. This is necessary to establish the degree of control required to maintain rivers and other surface waters so that, after treatment at a waterworks, they are suitable for domestic use.

The treatment of trade wastes has always been prominent amongst the Laboratory's researches, and in THE ENGINEER of November 25 and December 2 last, in the second of our series of articles entitled " Industrial Value of D.S.I.R. Research," the Laboratory's contribution to problems in the treatment of wastes from electroplating, and of pollution of surface waters by oil discharged from engineering factories, were discussed.

Survey of the Thames Estuary

Since 1948 the Laboratory has been carrying out a monumental research task, with the aim of drawing up oxygen-balance charts for the Thames estuary, and thus being able to predict the change in pollution in the river due to any suggested or actual change in the " polluting load," or in any other factor which affects the oxygen balance. This has now been largely achieved so it is possible to analyse the state of the estuary by relating it to the oxygen balance curves. Such a task has never been accomplished before, and has involved a number of new techniques, especially in the mathematics of the analysis, we understand. The report on this work is approaching completion ; it extends to about 250,000 words.

The primary purpose of the work was to provide information on which a departmental committee of the Ministry of Housing and Local Government could base recommendations for improving the condition of the estuary, which had been deteriorating for several decades until conditions had frequently become offensive during the summer months. The report of the committee had recently been submitted to the Minister and is shortly to be published.

It was previously known that the nuisance was due to the production of sulphide when the water became anaerobic owing to organic pollution, and the original task of the Laboratory was to study the factors which determine the distribution of dissolved oxygen—and also of nitrate which can supply oxygen under certain conditions. The relations between the dissolved-oxygen distribution and factors such as temperature and fresh-water flow have been examined, using both the results of surveys made by the Laboratory and the records over a very long period made available by the London County Council.

The load introduced to the estuary by polluting discharges of all types has been estimated, the largest source of pollution being the effluent discharged from the main sewage outfalls of the L.C.C. The amount of oxygen available from various sources for oxidising the polluting load has also been calculated, most of this oxygen being provided by absorption from the atmosphere.

During the period of the survey, the L.C.C. has made large extensions to the treatment plant at the Northern Outfall Works : new sedimentation tanks were brought into operation in June, 1955, and additional diffused-air plant was installed about four years later. Extensions to the Southern Outfall Works, where the whole of the dry-weather flow is to be treated in a diffused-air plant, are far advanced. The effect of the changes already made in the polluting load has been examined and that of the changes still to be made are being predicted.

The theory of mixing developed at the Laboratory has been used in calculating the distributions of the dissolved oxygen, ammoniacal nitrogen, and oxidised nitrogen in the estuary for widely different conditions of flow and temperature. Predictions of the changes in the condition of the estuary which could be expected to follow certain changes in the distribution and quantity of polluting matter discharged to the estuary, or in the quantity of heat discharged, or in the fresh-water flow, are now in progress.

Kinetics of the Activated-Sludge Process

Although the activated-sludge process for the biological oxidation of waste waters

has been used successfully for some fifty years, the kinetics of the process are not yet sufficiently understood to assess the scope for improvements in efficiency or to decide on the maximum rate of treatment which can be achieved for a given quality of effluent. There is currently a considerable interest in the possibilities of producing effluents of satisfactory quality, from wastes such as sewage, with aeration periods much shorter than are at present conventional in Britain. It has been shown, for instance, that providing the oxygenation capacity of the aeration units is sufficient, adequate removal of carbonaceous material can be achieved with retention periods in the aeration units of from one to two hours instead of the more usual four to five hours. However, it is not yet known how far it will be possible to go in this direction and under what circumstances, so an investigation is being made of the fundamental kinetics of the process and of the influence of operating conditions on performance. Among the factors which it is thought may be important are the method and intensity of aeration, the level of dissolved oxygen maintained in the aeration units, the degrees of turbulence and of longitudinal mixing, and the concentration of sludge. The results of preliminary studies at sewage works indicate that a large proportion of the carbonaceous matter is removed within the first few minutes after the waste and sludge are brought into contact in the aeration units, but that subsequently further purification occurs only at a very low rate. The rate of utilisation of oxygen by the sludge decreases gradually and its clarifying power is only slowly restored during aeration, suggesting that the initial rapid removal of organic matter may be largely due to adsorption and entrainment, the material removed being subsequently oxidised only at a relatively slow rate. Such an effect may well govern the maximum rate at which the process can be operated. In all the plants examined so far, no nitrification of ammonia occurred when the concentration of dissolved oxygen in the aeration units was below a critical level of about 0·5 to 0·7 p.p.m. Above this concentration nitrification appeared to proceed at a substantially constant rate, though this rate was low ; this may be because nitrifying bacteria have relatively long generation times and this in turn may be one of the main reasons why little nitrification is generally achieved in high-rate treatment plants.

A Comparison of Percolating Filter Media

An experiment was started in April, 1959, to compare the relative merits of media of various types and sizes for use in percolating filters treating domestic sewage. The media chosen for comparison were clinker, blast-furnace slag, rock (spilitic basalt), and rounded gravel, each in nominal sizes of about 1in and 2½in ; these were selected as being of greatest interest on the basis of over forty replies to a questionnaire. The media are being tested in a battery of eight filters, each of 16½ cubic yards capacity.

The results of two years' operation show that, with the exception of the 1in rounded gravel, the smaller media, treating Stevenage domestic sewage at a comparatively high B.O.D. loading of about 0·3 lb per cubic yard per day, have consistently produced better effluents than did the corresponding larger media, and that with each size of medium, the slag and clinker have given the best performance. With the 1in rounded gravel, ponding occurred for a short period in the winter of 1961, during which time the quality of the effluent produced was slightly inferior to that from the corresponding 2½in medium ; very slight ponding was observed with the other small media in this period but their performance was not affected. The average performances of the various media have been shown to correlate well with measurements of surface area per bulk volume of medium, the filters having the highest surface areas producing the best effluents.

Performance of Settling Tanks

The most common method of removing solids from waste waters is by settling under gravity in large open tanks. However, it is generally accepted that many settling tanks are not particularly efficient and that the basis for design is inadequate. The fundamental principles governing the performance of settling tanks are being studied at the Laboratory, attention being concentrated initially on the performance of humus tanks used for removing solids from the effluents from biological filters.

Studies on the settling properties of humus under standardised quiescent conditions indicate that the initial rates of settling increase with increasing initial concentration of solids and for a given concentration the rates vary with the type of filter. For instance, effluents from filters containing coarse media settled more slowly and contained a higher proportion of virtually non-settleable material than those from filters filled with fine media. Rates of settling were also found to vary seasonally. From the variations in the concentration of solids with time and depth, it appears that humus suspensions tend to flocculate to some extent under quiescent conditions and tests are being made to examine the possibilities of improving the settleability of effluents by stirring gently to promote flocculation. The influence of the design of the base of the filter and method of conveying the effluent from the filter to the settling tanks is also being examined. The results of the quiescent settling tests indicate that in ideal tanks, through which the liquid moves substantially with piston flow, both the overflow rate (the flow per unit of the superficial area of the tank) and the retention period will be important in determining performance. For overflow rates giving the quality of effluent required in practice, increasing the retention period beyond about three hours or the depth beyond about 5ft to 6ft appears to offer little advantage.

The performance and hydraulic characteristics of full-scale tanks at sewage works are being measured under various controlled conditions concurrently with measurements of the settling properties of the inflowing filter effluent. From the results it is hoped to be able to assess the effects of operating variables and the influence of differences in the design of the tanks. In this work considerable use has been made of recording photo-electric absorptiometers which monitor continuously the concentration of solids in the influent and effluent from the tanks. A rough measure of agreement has been obtained between the observed performance of the tanks and the predicted performance, assuming that various fractions of the effluent settled quiescently for periods indicated by the distribution of residence times in the tanks, as measured with radioactive tracers.

Scientific Shipbuilding

THE activities of the British Shipbuilding Research Association were outlined by Sir James Milne, Chairman of the Council, at a recent extraordinary general meeting of the Association.

The expenditure in the year to March 31, 1961, amounted to £415,635 compared with £330,000 up to March 31, 1960, and the estimates for the current year, he continued, provided for further expansion to nearly £550,000, with a heavy increase in extra-mural research, and including £25,000 for production research. With regard to the setting up of an organisation for Production Research Sir James declared that good progress had been made and that Mr. P. G. Hodgkinson had been recruited from the aircraft industry to take charge of the new section and had commenced his duties on January 1.

Last year, added Sir James, mention was made of developments in computer applications to shipbuilding problems, and of the intention to appoint research assistants at both Glasgow University and King's College, Newcastle. These men have since taken up their duties. The Committee set up by B.S.R.A. to co-ordinate various studies proceeding on the problem of expressing a ship's lines mathematically, has already issued reports to the member firms and to assist in progressing this work a special computer section has been organised within the Naval Architectural Department. Consideration has been given by the Research Board to the establishing of a central computer service and member firms are being consulted.

There are, continued Sir James, no important developments as regards the application of nuclear energy to merchant ship propulsion, since the Government has yet to announce its decision on the tenders received. Whatever the decision, there will probably be increased expenditure by the Atomic Energy Authority on a programme of research directed to the development of a reactor technology having better economic potential for marine purposes. The association believe the Authority will invite its team to co-operate with them and this could lead to an expansion of effort in this field and to a requirement for more staff.

He thought that the Intelligence and Library services could be utilised to greater advantage.

Sir Charles Connell, chairman of the Research Board, said that thirty-five reports had been approved for circulation to member firms, and that there were 103 items on the Research Programme, not all of which had been the subject of active work during the past year.

Sir Charles said that in the field of hydrodynamics the biggest single item on which they were engaged was still the methodical series of resistance and propulsion experiments with ocean-going merchant-ship forms. The results are now being analysed and cross-faired and a set of resistance charts based on the analysis of the L.C.B. (longitudinal centre of buoyancy) variations has been issued. New experimental work concerns the extension of the range of block coefficients up to 0·85 and the investigation of bulbous bows and of special stern forms, intended to give more uniform flow conditions for the propeller, which is of importance when there are high powers on a single shaft.

A standard code of procedure for bollard trials which has been drawn up has been approved by all their tug-building member firms ; work has continued on the model experiments to investigate the effect of bow and stern variations on the trawler series forms and four reports on this subject are to be issued.

A series, he continued, of experiments with a model of an 18,000-ton-d.w. tanker is to be commenced to investigate the effect on ship resistance of yaw and of the rudder required to counter it. It has been suggested that the fact that the ship is free to yaw and is maintained on course by the use of the rudder, whereas the model is usually constrained by guides, may have an important bearing on the ship model correlation problem.

Experiments covering a range of wave lengths and heights have been carried out with a model of the " Cairndhu " in long crested head seas.

and the ship motions, degree of wetness on the forecastle deck, and the effect on thrust and revolutions per minute were determined over a range of ship speeds. This work has been carried out to provide a basis for a systematic series of tests in waves and the choice of the "Cairndhu" model connects with the full-scale work of the Ships' Performance Committee. The results of experiments to investigate tank wall interference, known to occur when tests are made in waves at low speeds, indicate that this effect is not important in the practical speed range. Another report, approved for circulation to member firms, gives a new presentation of Schlichting's well-known chart for estimating the loss of speed in shallow water and an extension of the range of diagrams to cover the depths found on measured miles round the U.K.

The collection of stress data from ships in service continues, and a progress report which gives an account of the stress data collected from thirteen vessels over a period of four years is to be circulated to member firms.

Also under way, he said, is an investigation into the effect of surging of liquids in tanks on the loading induced on tank boundaries; full-scale tests have been carried out and model tests are in progress. A preliminary analysis of the records indicates that pressure variations on the bulkheads are governed primarily by vertical accelerations due to combined pitch and heave and to a lesser degree by fore and aft acceleration. In the full-scale tests there was no synchronism between the period of oscillation of the liquid in the tank and the ship's natural period and in the model tests both the length of the tank and the depth of the liquid is being varied to see if synchronism may arise, and if so, whether it will have any major effect.

Strain measurements have been made in the hull and superstructure of a large passenger liner during sea trials, to determine the structural behaviour of the superstructure, which incorporates one expansion joint, and high stress concentrations were found at the root of the joint. The shape of the root on one side was modified and resulted in a 50 per cent lower stress concentration factor.

During the past year thirty-one full-scale vibration tests have been undertaken, and the Association's staff has taken full-scale measurements of the propeller-induced pressure fluctuations on the hulls of a large passenger liner and a tanker; these will be followed by complementary model tests.

The experimental investigation of the laws of natural circulation in watertube boilers and the tests on inclined tubes are nearly complete, and the final stage will be to correlate the results and present them in non-dimensional form, while the present experimental programme will be concluded with tests to investigate circulation under conditions of rapid pressure drop.

Experiments on diesel engine cylinder wear, continued Sir Charles, have shown that for heavy fuels the cleaning of fuel by a purifier and a clarifier in series does not give a reduction in cylinder wear in comparison with untreated fuel.

As part of the investigations into the scavenging and supercharging of two-stroke engines, considerable progress has been made at Liverpool University on unsteady flow in exhaust systems. This work included the development of rapid calculation methods involving the use of electronic computers. Extensive measured-mile trials on a tanker of 18,000 tons deadweight which had been in service over six years, included trials in a number of conditions in order to find the effect of grit blasting the hull and polishing the propeller. Although there was an appreciable recovery in performance after grit blasting, the power was still some 13 per cent above the new ship level. Results of sea trials and roughness measurements carried out on a 32,000 tons deadweight tanker after six years in service, indicated that an increase in shaft horsepower of 27 per cent was required to maintain the service speed compared with the ship when new.

The chairman of the Research Board concluded by referring to the investigations into seakeeping which are being carried out jointly by B.S.R.A., the National Physical Laboratory, and the National Institute of Oceanography, and with the assistance of the Admiralty.

Underfloor Lathe for Railway Wheels

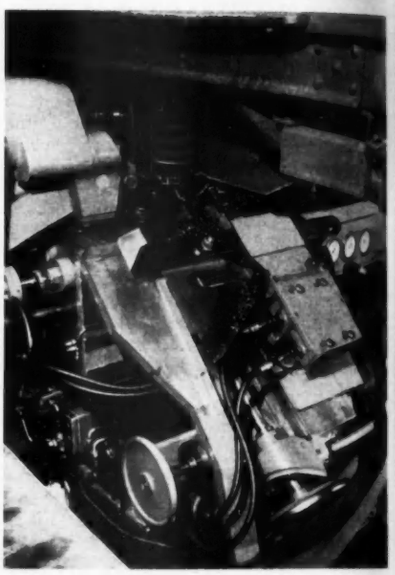
AN underfloor lathe for machining railway wheels recently placed in service by London Transport at its Northfields Depot was designed and constructed by the Scottish Machine Tool Corporation Ltd. The first of London Transport's underfloor wheel lathes, an experimental model installed at Golders Green Depot, and a second machine at Neasden Depot five years ago were designed to machine wheel flanges only, whereas the new lathe can machine the whole profile of the wheel.

In underfloor wheel lathes of earlier design, it has been usual for the vehicle wheels to be rotated by drive-rollers mounted on a horizontal axis parallel with that of the vehicle axle, the wheels resting on these rollers and the necessary adhesion being supplied by the vehicle's own weight applied through the axleboxes. It is pointed out that this dependence on adhesion involved limitation on the power which could be transmitted, and in the new machine, the drive is applied to the wheels by two pairs of rollers on vertical axes. These rollers are pressed hydraulically against the inner and outer faces of each tyre and exert balanced forces on each wheel so that no end thrust is applied to the axle.

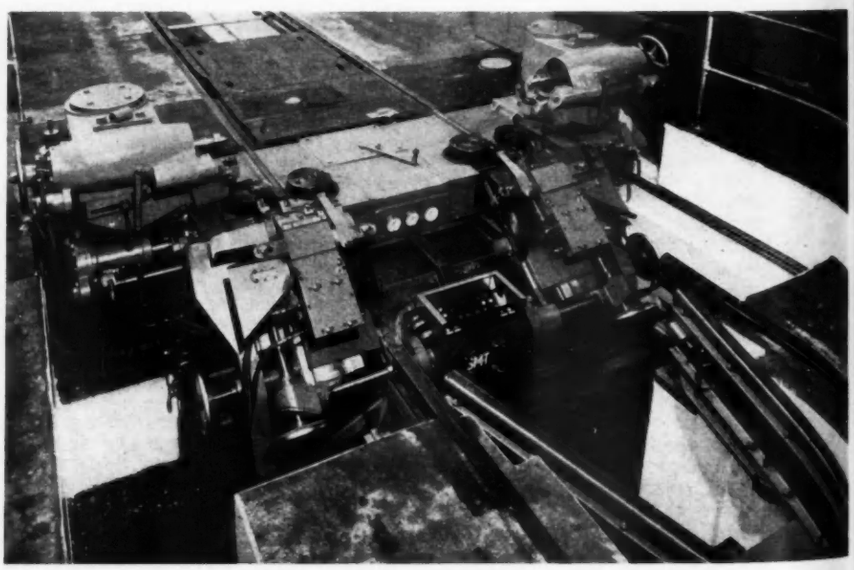
During machining the weight on the axle is relieved by hydraulic jacks, which are integral with the machine and are applied to the undersides of the axleboxes. Concentricity in turning is assured by holding the axle between live centres carried on power-operated columns by which they are raised into the working position and lowered clear of the rails when a vehicle is to be moved over the machine.

Carbide "throw-away" tipped tools, with clamp-type chip-brakers, are used on the machine which works on the copying principle with the tool holders moved by automatic hydraulic equipment across the wheel flange and tread under the control of a master profile. Each slide carries two tools and the wheels are machined in two operations using two templates. The first form tool is traversed across to machine the tread followed by the flange side with its root and top radii; the second tool is then used to machine the side face of the wheel. Quick power traverse movement of the tool slides in both directions is provided, with steplessly variable speeds and feeds, all operations being controlled from a push-button panel.

In operation, the axlebox covers on the axle bearing the wheels to be turned are first removed, with any shoegear and other equipment mounted with them. The vehicle concerned, which normally forms part of a three-car or four-car unit and is not uncoupled for the purpose of machining the wheels, is drawn forward on to the lathe by a power winch until the axle concerned is correctly positioned. Precise location is assisted by the provision of recesses in the railheads at the appropriate position. The tailstocks are then swung into the position on their columns and locked, after which the columns are elevated to raise the running centres to a level slightly above the centre-line of the axle. The hydraulic jacks are extended to engage the bottoms of the axleboxes and raise the axle until its centres are in line with the tailstock centres, which are then moved into engagement with the axles and locked. The swing rails used to bridge the working area while train movements take place are then moved clear and the tool slides are traversed hydraulically to the operating position and locked. The driving rollers are moved inwards by hydraulic power to press on the inner and outer faces of the tyres and the cutting tools are raised to the operating position for machining to proceed. After the completion of machining, the reverse sequence is employed to disengage the machine and allow the vehicles to be drawn forward to bring into position the next pair of wheels to be machined.



Left-hand tool slide of lathe



Underfloor wheel lathe in machining position with bridge rails swung clear of working area

Single-Engined, Four-Wheel-Drive Articulated Vehicle

A VEHICLE in which one engine drives all four wheels through only two universal joints has been evolved by Thwaites Engineering Company Ltd., Cubbington, Leamington Spa, Warwicks. This new configuration has been conceived in order to endow the contractors' dumper with improved off-the-road nobility, and it achieves this end with a vehicle that is compatible with the school of thought that civil engineering plant should be regarded as expendable; as an illustration, the front and rear axles are identical. This mechanical simplicity has been attained by steering the vehicle not by swivelling individual wheels, but by articulating the chassis about a pivot at the midpoint of the wheelbase. There is therefore no tendency for the front wheels to run faster or slower consequently than the rear when cornering, and it is possible to couple the front and back axles by a simple shaft. It is, of course, necessary to allow freedom in roll between the axles, and this is done in a radical manner by mounting the rear axle, the gearbox, and the engine on a sub-frame that is free to roll within the main structure of the vehicle; this arrangement means that the torque transmitted to the front axle acts to unbalance the weight distribution between the wheels on front and back axles, but this effect is considered negligibly small. There is no springing.

The 2-ton dumper is powered by an air-cooled twin-cylinder oil engine

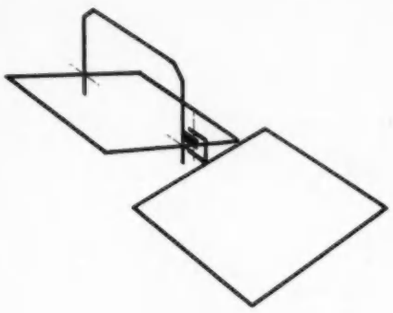
The new dumper, designed for a 2-ton payload, is powered by an air-cooled twin-cylinder Petter PH2 diesel engine giving 16·4 h.p. at 2000 r.p.m. A roller chain connects the engine to a clutch mounted on the gearbox input shaft; the Thwaites clutch can be likened to a drum brake, which is applied by a coil spring on the shaft forcing axially outwards a lever whose outer end is connected to the actuating wedge, which, on a Girling brake, moves parallel to the wheel axis—to release the clutch, the lever is forced back against the coil spring by a conventional clutch thrust race. Apart from the fact that brakes to operate in exposed positions are readily available, this form of clutch has the advantage of a self-servo action (although a leading-and-trailing geometry is in fact used), self-loading due to centrifugal force on the shoes, and ready adjustment through a large portion of the depth of the friction elements. The drive is taken from the camshaft of the engine, so that the capacity of the clutch needs to be large. The gearbox is a product of P.R. Motors, and gives three forward and one reverse ratios; changes are by dog clutches and are possible while the vehicle is moving.

From the gearbox output the drive is taken by another roller chain to the pinion shaft of the rear Salisbury hypoid semi-floating axle. At the end of the pinion shaft is mounted a Hardy Spicer propeller-shaft running to the front axle, which is the same as that at the rear; the sliding splines on the shaft accommodate the approach of the axles as the vehicle articulates. The universal joints on production vehicles are sealed full of grease on assembly, but a nipple is provided to lubricate the sliding splines. The differentials are conventional free-running devices. The tyres are 7·50×16, 8 P.R., and the vehicle is geared to reach 3¼, 5, and 10 m.p.h. in the forward gears. All wheels have 10in brakes operated by mechanical linkage.

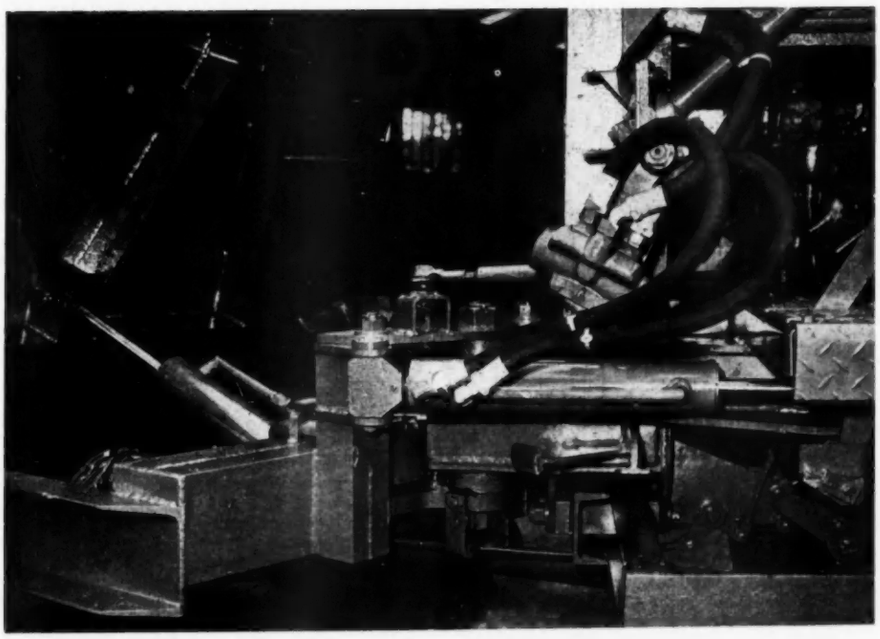
The steering of the vehicle is, of course, by power. The engine drives a Dowty pump which energises both the tipping and steering motions. Steering is effected by mounting a Marles control valve on the drop-arm and connecting it to the front chassis by a ball-jointed link; displacement of the valve feeds oil to the steering ram, which is interposed between the two parts of the chassis, so that the valve is not in the path of the main steering forces. This arrangement needs a multiplicity of flexible hoses, and in fact the proliferation of hose is a characteristic of the design; pressure fluid is carried over the main articulating joint by a pair of unarmoured hoses.

The skip is welded up from mild steel, and has a heaped capacity of 2 cubic yards. The skip is 6ft 4in wide and the length of the vehicle overall is 9ft 9in; the turning circle is less than 26ft in diameter. The empty weight of the vehicle is 33 cwt. Number plates, driving mirror, and an electrical system including a starter are optional extras; the vehicle is eligible to be licensed for use on the roads.

We have been afforded a demonstration of the prototype dumper, and observed that the turning circle and climbing ability are indeed remarkable, and that payloads can be moved over virtually unimproved ground. When the vehicle is stalled, it is usually through lack of wheel grip, although when it has followed a muddy track many times the ruts made by the wheels become deep enough for the differential casings to touch the ground. It will be clear that should the demand for off-the-road mobility not be satisfied by the existing vehicle, it is open to the constructors to incorporate larger or more flexible tyres, "Powr-Lok" differentials, or, *in extremis*, differential locks.



Principle of articulated construction

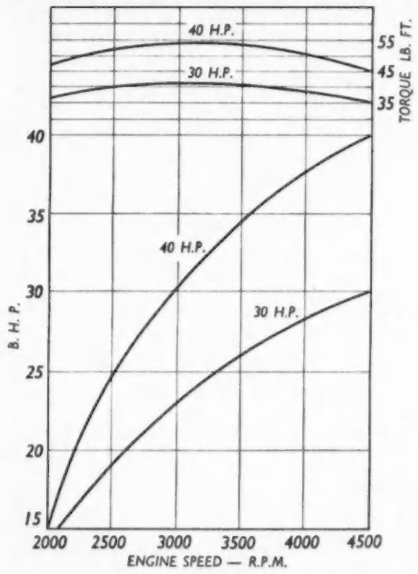


Steering mechanism of the articulated dumper. The drop arm carries the control valve alone, and the ram acts between the parts of the chassis. Beyond the ram is the steering pivot, and in front of it can just be seen the hoses for the tipping ram, restrained by a clip to prevent them being trapped under the body. Notice that the cable actuating the front brakes passes through a guide immediately below the pivot. In the extreme foreground is the subframe for the power unit, for which the front pivot, with grease nipple, can be seen

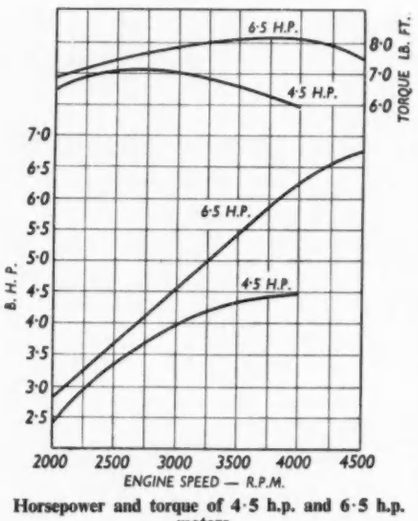
High- and Low-Powered Outboard Motors

TWO years ago the Perkins Group entered the outboard motor market and since then have been engaged in research and development work on this form of power unit. This has resulted in the production of a range of five motors which have powers from 4·5 h.p. rising to 40 h.p. and are suitable for propelling small dinghies to cabin cruisers. All the engines have been rigorously tested under working conditions in many parts of the world so that the design caters for widely differing atmospheric conditions, air temperatures and temperatures of cooling water.

All units are water-cooled ; have underwater exhaust ; use petrol-oil fuel and are available in short and long shaft form and with a number of different designs of propellers. The performance of four of the motors are shown in the graphs



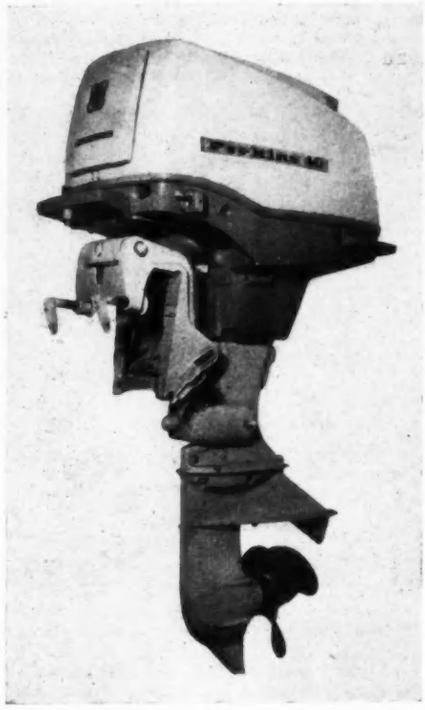
Horsepower and torque of the 40 h.p. and 30 h.p. motors



Horsepower and torque of 4·5 h.p. and 6·5 h.p. motors

reproduced herewith, on which are plotted brake horsepower and torque.

The largest motor is the 40 h.p. unit, illustrated herewith, which has a sealed-off power head suspended on rubber mountings to reduce vibration and noise. The amount of the latter is further reduced by a downward directed silencing system so that the motor is practically silent. Of 3⅛in bore by 2⅞in stroke, the twin cylinders have a piston displacement 44·12 cubic inches (722 c.c.) and the engine develops its power at 4500 r.p.m. The compact power head is a pressure die casting and is fitted with poppet valves to give relatively high torque at low speed, and provides good acceleration.



Outboard motor developing 40 h.p. at 4500 r.p.m.

Power is transmitted to the 10in by 13in, three-bladed propeller through spiral bevel gears, having a 21 to 13 reduction ratio, which are in constant mesh, to provide for forward, neutral and reverse movements. Protection of the propeller is by cushion hub and shear pin. A Tillotson concentric bowl carburetter with idle adjustment and fixed high speed jet is fitted, and the fuel pump is of single vacuum pattern operated by crankcase compression. Ignition of the 24 to 1 petrol/oil mixture is by flywheel magneto which incorporates a battery charging generator on the electric starting models. The latter have emergency manual starting while the manual starting models have automatic rewind and synchronised throttle and ignition with press-button magneto cut-out switch. Forced circulation cooling is employed, there being a submerged water pump having a neoprene impeller. Tell-tale holes at the rear of the motor provide a visual check on the circulation of the cooling water. All-enveloping top and lower shrouding provides adequate water proofing, and the throttle and gear shift remote control system are beneath the one-piece glass fibre top shroud, which can be released by a single finger-pressure catch.

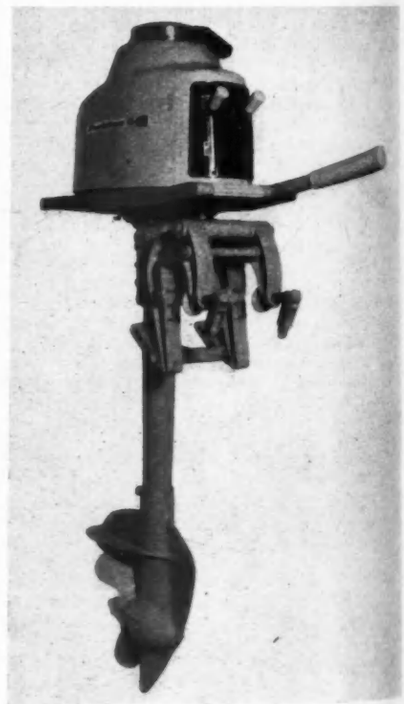
Stainless steel has been used generally for the motor, and the valve guide bosses are fitted with inserts, while the general surface finish of all working parts including crank journals, cams, cam followers, &c., is to a high standard. The bevel gears are of high quality hardened steel, and the pinion carrier and clutch dog have been designed for easy gear changing and long life. Built-in handles and stops protect the top and bottom shrouds when the motor is dismounted, while tilt handles are incorporated in the shroud, and a simple lock engages automatically as the motor is tilted. Fuel is carried in a remote tank of 5½ gallons capacity, and the motor, which is isolated from the transom by rubber shock mounts, weighs 130 lb in manual form and 7 lb heavier with electric starting.

At the other end of the power scale is the 4·5 h.p. model, running at 4000 r.p.m., which is suitable for small craft and as an auxiliary for sailing yachts. This unit, seen in our illustration, has twin cylinders of 2in by 1½in bore and stroke, a piston displacement of 9·42 cubic inches (154 c.c.) and a reed valve four-port power head. Starting is manual with automatic rewind, and ignition is by a featherweight flywheel magneto, while the Tillotson diaphragm carburetter is unaffected either by vibration or angle of operation. The fuel pump is of vacuum operated pattern, and cooling is by water, forced circulated by a submerged pump having a neoprene impeller. An important point of design is that the motor can be rotated through 360 deg., so that no reverse gear is required, and the 8in by 6½in two-bladed propeller is driven through 21 : 13 reduction straight bevel gears. Fuel consisting of a 16 to 1 petrol/oil mixture is carried in a remote tank of 2¾ gallons capacity. Simple lever throttle and choke controls are placed on the front of the shroud. The approximate weight of the unit is 40 lb.

The above description generally applies to the 6½ h.p. motor which runs at 4500 r.p.m., and weighs 60 lb, but has forward-neutral-reverse gears, an 8in by 6½in three-bladed propeller and a Tillotson concentric bowl with idle adjustment and fixed high-speed jet carburetter.

Other motors in the range include a unit which develops 18 h.p. at 4500 r.p.m., and has been developed from the existing 16 h.p. design. It has twin cylinders of 2½in by $2^{1}/_{32}$in bore and stroke, a piston displacement of 19·94 cubic inches (325 c.c.), a reed valve six-port power head, and drives a 9in by 11in three-bladed propeller through 21/12 reduction spiral bevel gears. The motor is supplied with either electric or hand starting, the respective weights being 95 lb and 85 lb. A 5½ gallon fuel tank is provided for the 21/1 petrol/oil mixture. The 30 h.p. motor develops its power at 4500 r.p.m., and has a bore and stroke of $3\frac{1}{16}$in by 2⅞in, a piston displacement of 42·35 cubic inches (690 c.c.) and a power head fitted with poppet valves. It is available with either electric and emergency manual, or manual with automatic rewind starting, and the manual version has a lightweight, water-proofed Bendix belt-driven " Mini-Mag " magneto. Except for the above particulars and that a 10in by 12in three-bladed propeller is employed the specification of the motor is the same as for the 40 h.p. motor described earlier.

The ratings of the range of Perkins motors have been approved by the Outboard Boating Club of America.



Outboard motor developing 4·5 h.p. at 4000 r.p.m.

SHORTER REPORTS

New Electronics Laboratory

THE Applied Electronics Laboratory of Ferranti Ltd. at Silverknowes, Edinburgh, was opened officially on October 12 by Sir Vincent Z. de Ferranti, chairman of the company. In this new three-storey building approximately 35,000 square feet of floor space are allocated to laboratories, a drawing office, a 30ft high installation bay for assembly of mobile radar equipments, a development workshop, and an administrative area. Permanent internal walls have been kept to the minimum, demountable partitioning being used to allow flexibility of layout. Work in hand at the laboratory for the Services includes "Firelight," a mobile radar equipment developed under Government contract which is associated with a guided missile system. This is already in quantity production, and orders have been received from one foreign government to date. Among civil projects in hand is a pulsed microwave data link developed for automatic telemetry transmission, having one master station to control up to fifty well-heads in an oil pipeline system at distances up to 25 miles. As a first step to a system of train identification, and eventually control, the possibility is being investigated of deriving information on train position and speed from signals detected at pole-mounted receiving surfaces beside the track, using the surface wave effect, and conveyed by line wire to a control centre. Another scheme in course of development concerns the remote measurement of currents in high-voltage transmission lines by the use of a transistorised detector clamped to the line and coupled electromagnetically to a metering circuit on the ground.

The Applied Electronics Department has also built a teaching machine based on the presentation of information to the student in relatively short stages, followed by questions. Progress to the next stage, or a return to the earlier lesson, accompanied by more detailed explanations, depends on the pupil's answers to the questions. Trials with machines of this kind are planned with the Edinburgh Education Department, and it is likely that Ferranti Ltd. will also use them for training its own apprentices.

River Ravensbourne Flood Relief Scheme

THE Rivers and Drainage Committee of London County Council has approved a scheme costing £3,605,000 to relieve flooding of the Rivers Ravensbourne, Pool and Quaggy, and their tributaries. The programme of work will be undertaken in four main stages, the actual programming being dependent on consultations with the Kent County Council who will be carrying out major improvements in Kent, and the Ministry of Agriculture, Fisheries and Food. The work will include the extension, construction, reconstruction and enlargement of concrete channels and culverts, including the reconstruction of the Lee Road culvert on the Kid Brook and the Southend Lane culvert on the Ravensbourne, and the provision, where necessary, of relief culverts. Other works will include the piping-in of various minor tributaries which are at present in earth channels.

The estimated total cost of the proposals in London is £3,605,000. Details of the proposals, with estimated costs, are being submitted to the Minister of Agriculture, Fisheries and Food, whose approval is required before the major works can start. Meanwhile, as much preliminary work as possible is being carried out. Negotiations with landowners and other interested parties will be necessary and it is not expected that it will be possible to complete the programme in less than seven years from the date of starting.

In order to deal with the problem of flooding in the Ravensbourne area, the L.C.C. had to obtain special powers. The measures now proposed follow the River Ravensbourne (Improvement and Flood Prevention) Bill which received the Royal Assent on August 3. This Act gives flood prevention powers to the Kent and London County Councils in respect of the River Ravensbourne and its tributaries. In London it also applies to the Rivers Ravensbourne, Pool and Quaggy, the Kid Brook, Kyd Brook and the Lower Kid Brook and to such parts of all tributaries, brooks and watercourses (whether open or covered) that flow into those rivers or streams.

Corrosion Exhibition

ON Tuesday, Wednesday and Thursday of last week Henry Wiggin and Co. Ltd., held an exhibition at Londonderry House, Park Lane, London. Under the title, "The Fight against Corrosion," the exhibition was laid out to illustrate the properties and uses of Wiggin corrosion-resistant alloys in many industries where plant is subjected to several forms of corrosive attack. In opening the exhibition Mr. R. E. Ansell emphasised the enormous cost of corrosion and the drain upon economic resources, while pointing out that corrosion cannot be avoided although an appreciation of service contions and the careful choice of materials can offset or minimise attack. The cost of corrosion to this country is estimated to amount to £600 million per annum in lost production, maintenance and material replacement, and the exhibition illustrates various types of corrosion covering : general wastage ; pitting ; galvanic, crevice, stress and inter-crystalline corrosion ; chemical attack ; effects of concentration, temperature and agitation. Strength properties, availability, corrosion testing were dealt with and there were exhibits of furnace equipment, marine engineering uses, and applications for the food processing, petro-chemical, paper manufacturing and kindred industries. In association with the exhibition two lectures were given, namely "Corrosion Testing of Materials for Chemical Plant Construction" by J. B. Maylor and "The Influence of Corrosion on the Design of Chemical and Allied Plant" by E. Warde, B.Sc., and in addition a Corrosion Forum under the chairmanship of H. Hodges, B.Sc., was held on the afternoon of Wednesday and Thursday. Also on each day of the exhibition there were two screenings of the following films : "Machining the Wiggin High-Nickel Alloys" ; "Corrosion in Action" ; "Welding of Wiggin High-Nickel Alloys" ; and "VPT681 —Nickel Tanker."

North East Coast Institution of Engineers and Shipbuilders

THE report of the Council for 1960–61 of the North East Coast Institution of Engineers and Shipbuilders records that nineteen papers were presented during the season and that the paper, "Marine Steam Turbine Design and Operation," by A. F. Veitch, was awarded the Engineering Gold Medal while the joint paper by Dr. T. W. F. Brown, T. A. Andvig and P. H. Cleff entitled, "The Pametrada Hydraulic Transmission," was awarded the M. C. James Medal. The report records a gift of £6000 received through Mr. Joseph MacGregor towards the provision of a scholarship in naval architecture at King's College. The completion of the reconstruction of the "Turbinia" and of "Turbinia House," the annexe to the Newcastle upon Tyne Museum of Science and Engineering, is noted. The Institution scholarship for 1961 has been awarded to J. S. Griffiths and D. Milton has gained the 1961 Swan, Hunter and Wigham Richardson Scholarship and Prize, while the 1961 Doxford Scholarship and Prize was awarded to R. J. Aird. Net membership at the close of the session on July 31 is given in the report as totalling 2387.

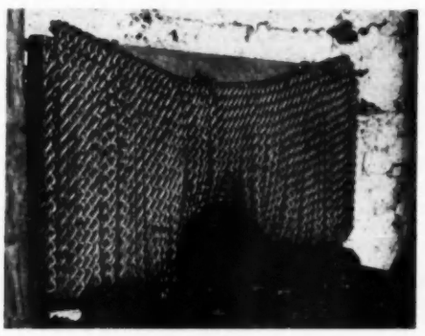
Report on Safeguarding against Colliery Explosions

Two years ago the National Coal Board published the report of the special sub-committee appointed by the Safety and Health Committee of the Coal Industry National Consultative Council to examine means of improving standards of safety and safeguarding against colliery explosions. Following the issue of this report, branches and sub-branches of the Association of Mining, Electrical and Mechanical Engineers discussed in detail its various sections. A technical committee of the association was formed to consider the comments of members in these discussions and it has now prepared a memorandum summarising the conclusions reached. This memorandum has now been published in the journal of the association, and it provides supplement to the original report.

The sections of the report to which there is particular reference and further recommendations of importance made include those on ventilation ; protection and siting of motors and switchgear ; protection of electric cells ; earth leakage and overload protection ; standards of practice ; and human factors. The recommendations and suggestions are based upon the experience of the members of the association.

Twisted Chain Air Seal

A NOTE received from the National Coal Board states that Mr. P. Thorp, a ventilation engineer in the N.C.B. East Midlands Division, has proved that suspended rows of cross chain twisted link can be used to provide a very efficient, cheap, permanent and simple air seal at places where a coal-carrying conveyor has to pass through an airlock. As shown in the illustration individual lengths of chain are so

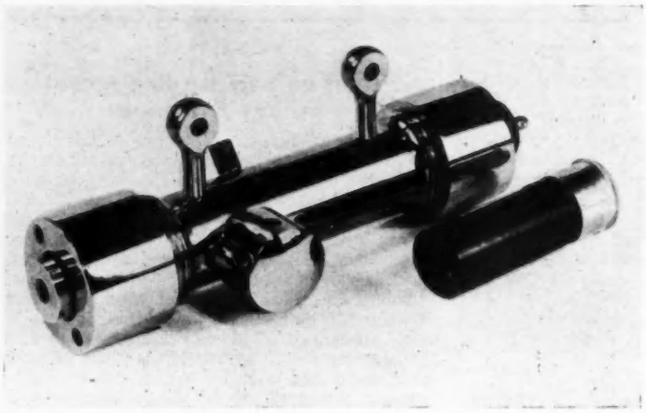


Curtain formed by rows of twisted chain as used to provide an air seal on a coal conveyor

placed so as to form (normally) three curtains over the opening to be sealed. Adjacent chains in the same curtain, and the curtains themselves, are hung close together, the links fitting into each other and forming a closely knit barrier against air-flow. The lower ends of the chains mould themselves to the profile of the coal-load passing under the barrier, thus avoiding concentration of air-velocity and reducing dust pick-up to a minimum.

The note points out that air leakage associated with the present conventional type of "belt" door often produces a dust problem, is wasteful and costly, and adversely affects the ventilation of the production faces. The use of a chain air seal at air crossings to allow continuous passage of material from the upper to lower roads has been found superior to the trap door or airlock door systems. There is also a potential application for this design of seal at belt conveyor transfer points where the rows of suspended chain would reduce the degradation of coal and formation of dust.

SHORTER REPORTS *(Continued)*



Combustion chamber seen from nozzle end : on the fan side is the pressure tapping. The cartridge is detonated electrically

Instructional Rocket Test Plant

THE equipment for the study of thermodynamics and combustion manufactured by P. A. Hilton and Co., Sydneyville House, New Road, Radlett, Herts., which, it will be recalled, includes a ram-jet test plant (page 790, December 11, 1959), has now been supplemented by a solid propellant rocket test rig. The motors are similar to starter cartridges and have electric ignition ; they may be transported under the same conditions as apply to shotgun shells. The combustion chamber is made of stainless steel, and the nozzle is removable. The chamber is safeguarded by a bursting diaphragm.

The finite running time of the solid propellant motor demands automatic recording, and a moving chart driven by a synchronous motor is marked by two pens, one driven by a large Bourdon tube sensing chamber pressure, and the other by the movement against a flexural spring of the linkage carrying the chamber. If electronic recording apparatus is available, the record of thrust may be obtained by attaching strain gauges to the spring beam. The mass of the charge can be ascertained by weighing before and after burning.

The rig is only 28in by 15in by 15in, but requires to be ducted to atmosphere or an extractor system. It is supplied complete with two convergent and two convergent-divergent nozzles.

[Reply Card No. 1305]

Production of Tools for Processing Sheet Metal

FIFTEEN years ago the Clearing Division of U.S. Industries Inc., through its British agents, the Rockwell Machine Tool Company Ltd., came to an arrangement for the manufacture of Clearing presses and press brakes in this country by Vickers-Armstrongs (Engineers) Ltd., of Newcastle upon Tyne. Since that time the British firm has manufactured over 1550 machines for users in this country and overseas. These machines, made fully to Clearing designs and specifications, have ranged from 30-ton welding presses to 3000-ton chassis rail stamping presses with up to 25ft between the uprights. The construction of these presses has hitherto been carried out in two different Vickers-Armstrongs works at Newcastle upon Tyne, and recently, to increase the productive capacity and efficiency in manufacture, the firm re-organised the two sections and brought them together under one roof.

A considerable amount of new plant and equipment has been laid down for this single class of production, and the new division covers about 22 acres of the works, with three main shops for machining, fabrication and assembly of the presses. Indicative of the capacity now available is the fact that the fabrication section can weld plate parts up to 12in thick and produce welded structures up to 100 tons in weight. Heavy machining is carried out in what must be one of the best equipped shops of its kind in this country. Our illustration shows one section of the shop where two Asquith 6in spindle floor type milling, drilling and boring machines are mounted on a common bed. Each machine has a vertical spindle traverse of 10ft, a horizontal traverse of 63ft 6in and a workplate area 85ft long by 15ft wide. With this arrangement additional workpieces can be set up for machining whilst the two spindles are engaged. In the illustration the advantage of this layout can be seen ; the machine in the foreground is machining the feet on the fabricated bed for a single-action double-crank Clearing press, whilst that in the background is working on a sliding bolster for a die spotting press. On the workplate in the centre between the two machines there has been mounted the welded crown of a press ready for machining.

In the course of a recent visit to see the new production lines we were also shown the special lines which have been installed for the manufacture of the " Torc-Pac 40 " clutch and brake unit developed for large Clearing pressses. This unit, which is designed to facilitate higher rates of production with a considerable reduction of press down-time, was described in our issue of February 17, 1961, in connection with another development of Clearing—a range of " Torc-Pac " open back inclinable presses. These presses in 22-, 32-, 45- and 60-ton capacities are now being made at the Crayford works of Vickers-Armstrongs (Engineers) Ltd.

In 1958 the firm of Vickers-McKay Ltd. was set up jointly by Vickers-Armstrongs (Engineers) Ltd., the McKay Machine Company of the United States, and the Rockwell Machine Tool Company Ltd., to manufacture and market the American firm's products. These products include press feed lines, cut-up lines, tube making plan and sheet corrugating plant. De-coiling lines of this design, such as are supplied to the motor-car industry, can take 6ft wide steel coils, weighing up to 20 tons. From the de-coiler the material is passed on and cleaned in a washing machine and then taken on through a levelling or flattening machine before being delivered into a Clearing press for blanks to be produced, two at a time, at fifty per minute.

A similar, but more compact, line, known as the " McKaymatic " die shear line, incorporates a flying shear of novel design which accurately cuts sheets to length under control of transistorised electronic equipment. With this line any length from 12in to 999in can be programmed manually or by punched cards or other information storage methods. The average output is approximately 15 tons of sheet per hour at the rate of thirty pieces per minute. For the motor car industry automatic lines are also made for rolling wheel rims for all types of vehicles.

The American company has for many years been active in the manufacture of machinery for the sheet steel industry supplied by Wean Engineering Company of Warren, Ohio, for continuous pickling, galvanising, electrolytic tinning and high-speed shear lines. Vickers-McKay Ltd. at present has in hand some very large plants of this type for the British steel industry. The new Colville continuous sheet steel mill installation at Ravenscraig, Scotland, will contain six large uncoiling, upcoiling and levelling machines designed by McKay and built by Vickers-Armstrongs (Engineers) Ltd. for Wean-Miles Ltd.

Heavy machine shop of power press making division at the works of Vickers-Armstrongs (Engineers) Ltd.

Institution of Engineers and Shipbuilders in Scotland

At a meeting held on October 3, I. M. Stewart, B.Sc., gave his presidential address, entitled "In Search of Economic Stability and Security," before the Institution of Engineers and Shipbuilders in Scotland. In his opening remarks he expressed the opinion that to-day's most vital questions related to economic and industrial conflicts and that recurring national crises adversely affected our competitive position. Lack of export incentive and late entry into the Common Market are a cause for anxiety for, although not complete without British participation, such participation without adequate preparation will result in hardship, and he suggested that British workers be sent to Europe for educational purposes. Mr. Stewart welcomed proposals for a National Economic Council but wondered how the T.U.C. would resolve the difficulty of joining a planning council having a wage restraint policy. He went on to state that the brake on productivity was psychological and was unaffected by economic manipulations, for a protected economy had resulted in a rigid short sighted viewpoint unable to understand the need for long-term discipline.

Although not condoning irresponsible strikes, the President thought that the thinking of the trade unions was conditioned by past events and that strikes were largely caused by the present impossible system. He briefly traced the growth of the trade unions and associated legislature, gave tables revealing the pattern of membership and political relationship together with contributions to party funds. This industrial pattern, continued Mr. Stewart, is peculiar to this country but it is essential to assimilate lessons from European rule books in order to compete with Europe. This was reinforced by a table giving the number of disputes, of workers involved and of working days lost and the figures revealed that only Italy had a worse record than Britain, and that, with the exception of France, in 1959 this country lost about 100 working days for every one lost elsewhere. Statistical evidence, he said, confirmed that security was the main concern of the average worker who regards profits as his enemy and, having little knowledge of national economics, fears anything which creates economic instability.

The majority of workers were not irresponsible, have small faith in nationalisation, but can be exploited emotionally by those who misuse democratic freedoms, and are partisan to political development while being reactionary to innovation. Labour problems in shipbuilding, continued Mr. Stewart, were not exceptional to that industry : he mentioned the motor car industry and also the docks, where the present system of organised idleness breeds troubles. He touched upon trading advantages enjoyed in other countries and labelled as imprudent and quixotic the publication of the D.S.I.R. report.

The President went on to examine the position of the T.U.C. with regard to taking disciplinary action to deal with unofficial strikes and contrasted union belief in planned economy with union insistence on autonomy. He was critical of the Government's ignoring union defects yet investigating shipbuilding and other industries, and thought that wage inflation unrelated to production damaged the economy.

To resolve present anomalies the President outlined a scheme which called for Government legislation to establish a new non-political organisation to which the trade unions would belong and from which they could draw funds to finance educational and other activities, provided that they conformed with certain codes of practice. Finance for the scheme could come from a levy on industrial and commercial profits and means would be found to iron out inequalities in wage structures. All benefits accruing must be dependent upon the elimination of unofficial strikes, restrictive practices and all other measures damaging to the country's economy and industrial reputation. The proposed organisation would correspond, in effect, to a public trust and the funds available would provide pensions which would not be dependent on the fortunes of individual firms. Mr. Stewart went on to set out certain points with regard to the rationalisation of wages on a national basis —which would help to give more individual freedom, help the unions to become truly democratic, remove fear of victimisation and coercion, and bring into being a national force for improving industrial relationships. The proposals, he thought, combined with improved discipline, greater integrity and the removal of mass psychological conflict, would generate an industrial climate in which our national economy would prosper.

Improved Cooling on Wire Drawing Machines

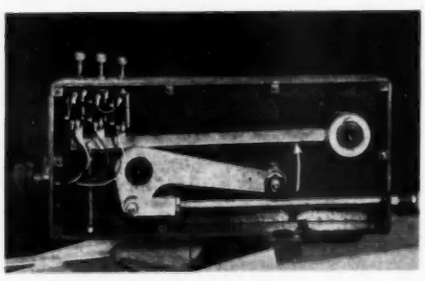
Any increase in the maximum speeds and outputs of machines drawing high-tensile wire must be accompanied by a corresponding improvement in the cooling efficiency, if the loss in ductility which results from drawing at elevated temperatures is to be avoided. The British Iron and Steel Research Association has published the results of its researches into the problem of cooling on wire drawing machines, and has shown that improvements in speed of about 30 per cent can be gained by preventing the formation of rust deposits on the internal surfaces of the capstans. This can be achieved by plating the walls with a non-corrosive metal, or by using a chemically-treated recirculating water supply.

Still further improvements are possible by combining the above feature with a new "narrow gap" capstan. In this the cooling water is passed through a narrow annular channel between the drawing ring and a stationary inner cylinder. This ensures that the flow is turbulent and brings about efficient heat transfer. During pilot plant trials it proved possible to achieve a 40 per cent increase in production rates of heavy gauge wire and an increase of 20 per cent on lighter gauges. The design has the advantage that it can be fitted to most existing machines with little modification.

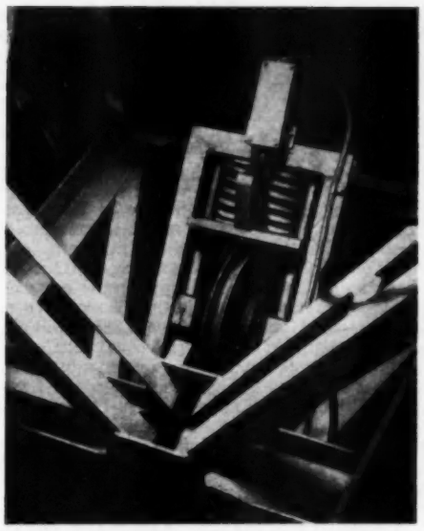
It is not only on mills requiring greater outputs that the ideas can be advantageous. For example, it should be possible, by adapting the new design on plant of normal output, to achieve satisfactory cooling without the use of an external air blast. Alternatively, the same output could be obtained with a reduced water consumption. A licence to manufacture the equipment on a commercial basis has been granted to The Marshall Richards Machine Company Ltd., Crook, Co. Durham.

Safety Devices for Tower Cranes

To prevent overloading of tower cranes and give advance warning of excessive load or radius a safe-load indicator and a constant-load limiter have been introduced by Babcock and Wilcox Ltd. These devices are separate units designed to operate in conjunction with a common visual warning, audible alarm, and cut-out, and together form a complete system that gives full protection. They were developed by the materials handling division of Babcock and Wilcox Ltd., for inclusion as standard equipment on the British-built "Babcock-Weitz" saddle-jib tower cranes, and they can be adapted for use on other types of tower crane to provide greater safety and convenience of operation. The units operate automatically and are designed to meet the Ministry of Labour's Building (Safety, Health and Welfare) (Amendment) Regulations, No. 1553, 1958, which require safe-load indicators to be fitted to cranes used on building sites.



Safe load indicator with cover removed to show mechanism and micro-switches



Constant load limiter mounted on a tower crane structure

The "Simcox" safe-load indicator to be seen in our first illustration is designed for mounting on the main tie-bar that supports the jib by linking it to the top of the tower. It safeguards the crane against excessive loads and/or radius. This indicator is wired in parallel with the "Simcox" constant-load limiter, which is embodied in one of the hoist-rope pulleys, and provides protection against excess loads on the hoist-rope, irrespective of the radius. Both units include mechanical means for operating micro-switches which, as the safe working load is approached, give a preliminary visual warning and then an audible alarm before tripping the control circuits to safety. After tripping has occurred, no outward travel of the crane's saddle or raising of the load is possible, but inward travel and/or lowering of the load can still be effected by the normal controls. As soon as the excess of load or radius is removed, all circuits are restored for normal working by use of the "start" control.

Operation of the safe-load indicator is based on a continuous comparison between the length of the loaded tie-bar and the constant length of an unstressed operating rod. This rod is fixed to the tie-bar at one end, and at the other end is pivoted to the first of a series of levers that amplify the minute stretch in the tie-bar caused by a load on the crane's hook. The rod is supported against sagging along its length and on excessive stretch it operates in sequence three adjustable micro-switches, which serve the warning and alarm signals, and the cut-out.

The amplifying levers and switches are enclosed in a weather-proof box (approximately 4in by 8in by 20in), which is fixed to the tie-bar. External grease nipples provide means of easy lubrication of the bearings and projecting adjusting screws fitted with lock-nuts enable the switches to be set precisely and permanently. The normal setting of the sequence is for visual warning at 85 per cent and audible alarm at 95 per cent of the safe working load, and the circuit-trip is set to operate when the safe working load is exceeded by 2½ per cent.

The "Simcox" constant-load limiter, shown in our second illustration, is essentially a spring-mounted pulley, mounted at the junction of the tower and the jib, and it is designed to produce a deflection of the springs when a load is on the crane's hook. This deflection is proportional to the load and is transmitted progressively to a set of three adjustable microswitches enclosed in a weather-proof box. The normal setting is for visual warning at 85 per cent and audible alarm at 95 to 97 per cent of the safe working load, and the circuit-trip is set to operate when the safe working load is exceeded by a predetermined amount. The common alarm unit, containing the warning light and alarm bell, is fitted in the crane's control cabin or other control station.

[Reply Card No. 1249]

SHORTER REPORTS *(Continued)*

Admiralty Experience of Glass Reinforced Plastic Boats

FOR the past ten years the Royal Navy has been evaluating the use of glass reinforced plastic for boats under thirty feet in length, as a result of which Glass Reinforced Plastic (G.R.P.) construction up to this length is now contemplated where numbers will justify the mould cost. The design of larger boats in G.R.P. is under consideration. Trials carried out with glass reinforced plastic boats have covered craft from 9ft to 27ft in length, operated at speeds of from six to 16 knots. Experience has been gained with resin and reinforced material on G.R.P., composite, sandwich, round bilge and hard chine designs, and exhaustive tests using both cold-set and hot-set construction have been carried out all over the world.

One of the advantages and financial saving accruing from the use of G.R.P. boats in the Navy is the resultant release of manpower which would otherwise be engaged on the maintenance of traditional wooden boats. A further saving would be made with G.R.P. by abolishing the present need for sheathing of wooden boats used in tropical waters. The adoption of G.R.P. in small boat construction in the Navy would mean resultant increases in the speed and ease with which boats can be repaired both on board and at shore bases, compared with the wooden boats, where removal of considerable amounts of planking is often necessary. One disadvantage was the decline in appearance of the G.R.P. boats after considerable use in Fleet service, but recent paint tests carried out by Admiralty research establishments have established that this can be overcome for all except the fast planing boats by traditional brush painting.

In 1951 two commercial dinghies were purchased ; the first was a 9ft 3in boat weighing 96 lb, using resin bonded glass and diagonal mat cold lay-up construction, and the other a 7ft 7½in boat weighing 90 lb and using resin bonded glass and swirled mat hot-set construction. These were tested initially over a period of six months with no difference in ultimate strength and no need for repairs. To gain further experience with cold and hot-set constructions, two 20ft motor dories were tested. One was constructed using the brush-on method over a female mould, the other using the heated pressure bag hot-set method over an aluminium female mould. However, in view of the small number of boats required, the expensive hot-set method was not justified.

The next boat acquired was a 25ft medium speed motor boat of cold-set construction using shell and frames of G.R.P. with gunwale, hog, keel and stem of timber, through bolted. The first five months service in hot weather in the Mediterranean showed that the hull stood up "moderately well" to Naval handling and withstood impact as well as wooden hulls. The surface tended to crack and craze, and was susceptible to damage by abrasion when coming alongside. From the Naval viewpoint a major disadvantage was that appearance of the boat soon deteriorated. It was painted but paintwork peeled off below the waterline and rubbed off easily. After a further two-and-a-half years' service the boat was surveyed (total service four to five years) and was found to be in better condition than a wooden boat of comparable age. Abrasions and deep scores of the hull did not show evidence of ingress of water, delamination or leaching out of the resin ; through-bolting of wooden members was not a good feature ; while impact resistance of glass mat reinforcement proved satisfactory for Service use ; appearance was poor.

Direct comparisons between composite and all-G.R.P. construction were made with four 27ft motor whalers obtained in 1957–58 : two were of composite construction and two of monocoque construction. Reports indicated that the G.R.P. hull was satisfactory while repairs and maintenance were easier.

Experience has also been gained with plastic sandwich construction on a 16ft fast motor boat. The hull consisted of expanded P.V.C., ⅞in thick, sandwiched between laminations of G.R.P. This provided inherent buoyancy, a clean internal surface and a degree of rigidity sufficient to allow frames to be dispensed with. The boat was finished in G.R.P. throughout. Trials showed some lack of adhesion of G.R.P. laminates to P.V.C. core but it was considered that the rigidity of the shell and elimination of frames given by the sandwich method of construction was a sound technique for small boats.

Following extensive prototype evaluation and modification, the boat was given a further trial as a result of which it was found that the G.R.P. showed no sign of surface deterioration ; the non-skid surface of the G.R.P. deck was not adequate ; a reasonable appearance could be maintained by washing with water and detergents.

As a result of this ten-year trial period the Admiralty has formulated a standard repair kit for plastic repairs, which may also be used for semi-permanent plastic repairs to wooden boats.

As a result of the trials the conclusions reached are as follows : low alkali glass is more suitable for marine work ; glass reinforcement prior to use must be dry ; glass mat, although not so strong as glass roving and cloth, is satisfactory for boat hulls up to 30ft in length of low or medium speed with inboard engine ; and the introduction of glass woven roving between layers of glass mat should be considered for craft above 30ft. Concerning polyester resins it was found that : clear resin for all other than the gel coat of a laminate aids inspection ; a proportion of flexibiliser is necessary for gel coat resins to prevent surface crazing ; while epoxide resins should be used for securing items after the hull has cured, and is suitable for use as a repair resin.

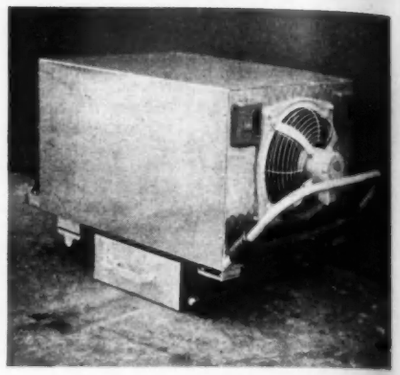
The use of fillers in the resin mix is not recommended because they increase water absorption properties, and, with particular reference to the gel coat, produce a rigidity resulting in star shakes and other surface blemishes. With relation to construction the trials showed that : cold set hand lay-up techniques are satisfactory, provided that they are carried out under temperature controlled conditions ; resin tends to crush around fastenings ; through fastenings should be kept to a minimum because of seepage along the fastenings ; wooden engine bearers are more economical than G.R.P. for Service boats because of alterations required when re-engining. Other results indicated that : monocoque construction, because of the numerous moulds needed, should be considered only where very large numbers off are required ; and G.R.P. hulls up to at least 16ft in length can, by use of sandwich construction, be given sufficient rigidity to dispense with longitudinal and transverse framing and buoyant material can be efficiently incorporated.

The Service characteristics noted are that : G.R.P. boats, up to at least 30ft in length, are adequate for Service requirements in respect of strength, impact and watertightness ; maintenance is appreciably less than that required for wooden boats ; for tropical service the boat does not necessitate the fitting of sheathing : marine growth is easily removed ; repair is simpler and quicker than repair of wooden boats ; and that "fall off" of appearance can be overcome, for other than fast planing craft, by painting.

Industrial Air Dryer

THE accompanying illustration shows a machine called the "Trembath industrial dehumidifier" which extracts water from the air. It operates by refrigeration, its chief component being a "Frigidaire" condensing unit. Moisture-laden air is drawn in at one end of the machine by a fan, forced over the evaporator and cooled to a temperature below its dewpoint. The moisture condenses on the evaporator coils and drains into the portable tank which is fitted under the machine, or runs to waste through a hose. The air then passes over the refrigerant condenser, causing its temperature to be raised. If the ambient temperature is below 55 deg. Fah. six 500W thermostatically-controlled heater bars come into operation, resulting in warm dry air being dispersed and recirculated at the rate of 600 cubic feet per minute.

The dryer will remove up to 6 gallons of water in twenty-four hours under a design condition of 55 deg. Fah. dry bulb temperature and a



Industrial air dryer

relative humidity of 80 per cent. It is mounted on a welded steel frame with solid-rubber-tyred wheels and swivel castors and is encased in sheet metal. It is offered for use primarily to building contractors for drying out plaster, but a wide range of applications is claimed. The running cost of the machine is stated to be about 6d. per hour, or approximately 1½d. per hour when the heaters are not operating. The Trembath industrial dehumidifier is distributed by Greenham Equipment, Ltd.

[Reply Card No. 1233]

Frequency Measuring Equipment

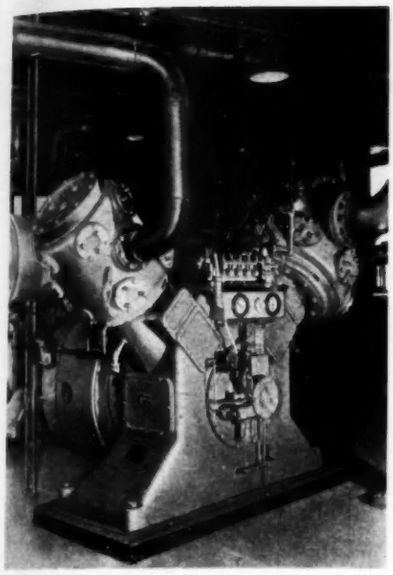
SEVERAL items from the Schomandl range of high-frequency measuring equipment were demonstrated in London recently. This equipment is handled in the United Kingdom by Elliott Bros. Sales Agencies Ltd., Boreham Wood, Herts, a subsidiary of Elliott Bros. (London) Ltd. The apparatus included the FD1 portable heterodyne frequency meter for commercial radio systems, in which a single reference oscillator tuned by several decade-calibrated dials takes the place of the conventional system using separate coarse and fine reference oscillators. The meter is designed for convenient transport and is of upright form, enabling it to be used readily on the seat of a car beside the operator. Another item shown was the SN2/34 master oscillator for the control of commercial short-wave transmitters, which is set up to the desired frequency by means of decade-calibrated selector switches. Further applications of heterodyne frequency measurement were seen in a series of frequency decades extending into the microwave region. In these equipments a difference frequency is formed between the unknown frequency and the reference standard frequency, the difference being either tuned down to zero beat or compared against a second standard frequency on an oscilloscope. It may also be measured by a direct-reading frequency meter or electronic frequency counter, or be recorded by a frequency drift recorder. Apparatus of this kind has the advantage over frequency counters that it can be used for generating standard frequencies as well as for measurement.

[Reply Card No. 1258]

Heavy Duty Air Compressors

A NEW range of heavy duty, water cooled, double acting, stationary air compressors, in which the cylinders are set 90 deg. apart, has been introduced by the Consolidated Pneumatic Tool Company Ltd., of 232, Dawes Road, London, S.W.6. This "Y" class range, as it is known, is available in seven sizes with outputs of from 372 to 1615 c.f.m., at pressures of from 80 lb to 125 lb per square inch, the horsepowers covered being from 75 to 300 b.h.p. Multistage units are available for pressures of up to 3000 lb per square inch and compressors can be driven by flange mounted motors, vee belt drives or direct coupled motors.

These compressors have ribbed and webbed frames of high strength cast iron integral with the crankcase, and each frame neck has a stuffing box with double metallic wiper rings to prevent



Heavy duty air compressors

egress of oil along the piston rods. The guides which accommodate the double acting crosshead are also cast integral with the frame to give rigidity to the frame neck and to ensure a permanent alignment.

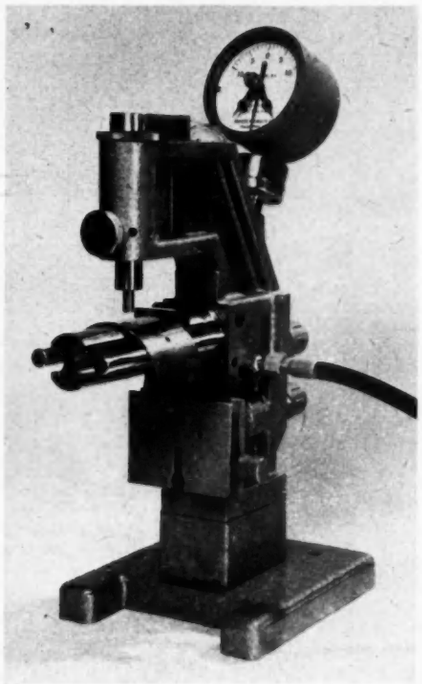
The crankshaft, drilled for pressure lubrication, is supported by three self-aligning, spherical roller bearings. The crosshead end of each connecting rod carries a solid, bronze bushing, the crank pin end having a shim adjusted, bronze-backed babbitt lined split bearing secured by two alloy steel bolts. The crossheads, which are one piece steel castings, overtravel the guides and this, combined with the large bearing area, ensures that wear is held to a minimum and is evenly distributed. The need for adjustable shoes is eliminated in this crosshead design by the use of a full floating alloy steel crosshead pin.

The cylinders, of one piece construction, have the valves disposed radially in each end of the barrel and the entire area of the cylinder head is water jacketed. The first stage piston of aluminium alloy and the second stage piston of cast iron are of equal weight to give balanced operation and each has two compression rings. The "Simplate" valves consist of heat tempered and ground concentric discs operating over annular ports in a valve seat. The discs rise and fall against volute springs and are retained in position by a valve keeper that guides the valve at three points 120 degrees apart. A shell and tube type intercooler space between the cylinders has a removable nest of tubes. The outlet is formed into a moisture pocket to trap condensed oil and moisture, an automatic drain trap, pressure gauge and safety valve being standard equipment. The photograph we reproduce shows a typical compressor driven by a flange mounted motor.

[Reply Card No. 1277]

Adjustable Wall-Thickness Gauge

AN adjustable wall-thickness gauge designed for measuring the wall thickness of plain bearings, cylindrical bushings and similar parts has been developed by Teddington Industrial Equipment



Adjustable wall-thickness gauge for cylindrical components from 1½in to 7½in inside diameter and up to ⅝in thick

Ltd., Sunbury-on-Thames, Middx. This gauge, illustrated above, will handle components from 1½in to 7½in internal diameter with up to ⅝in wall thickness and check concentricity.

The instrument uses open gauging nozzles so that there are no contacts to mark the work piece, and its tungsten carbide wear surfaces are superfinished.

For setting purposes a pneumatic span-setting master is built into the gauge and the pneumatic calibration can be readily checked by turning a knob. A nominal size master is used to enable the adjustable upper nozzle to be positioned correctly for the particular size of work piece. This master may be either a flat slip gauge or a work piece of known size.

To give fast, easy measurement, the gauge is designed with a maximum clearance of 0·002in to 0·003in beyond the thickest part that can be measured at any particular setting. The indicator gauge is liquid filled and sealed, giving a fast positive pointer movement.

The gauge may have one of two working ranges—0·001in/0/0·001in reading to 0·0001in (magnification 1800) or 0·002in/0/0·002in reading to 0·0002in (magnification 900). An air supply at any pressure between 60 lb and 150 lb per square inch is required and the instrument is supplied complete with air filter supply, pressure gauge and connecting hose.

[Reply Card No. 1276]

Resilient Tyres

A TYRE which is highly resistant to the abrasive and incisive environments prevailing in industry is now being manufactured under licence in this country. The "Mitco" tyre offers greater resilience and traction than a solid rubber tyre, but does not possess the liability to deflation of the pneumatic tyre; hence it commends itself for works trucks, whereon deflation of a tyre might have a catastrophic effect upon the stability. These considerations led to "Mitco" tyres being adopted for the Hyster trucks of the Steel Company of Wales, and they are now being made by the Watts Tyre and Rubber Co. Ltd., of Lydney, Glos. These tyres are assembled from a large number of wedge-shaped elements of rubber-bonded fabric, retained in a closely packed annulus by, as far as we can discover, a strong garter spring; this spring gives the tyre sufficient resilience for a wheel to bounce if it is dropped on a hard surface. Because of this construction, the tyre is far less easily cut than a solid rubber moulding, while the "tread"—the depth of material which may be allowed to wear away—is much greater than on a pneumatic tyre; the tyre is also less affected by oil, soluble oil, and other agencies harmful to rubber.

The "Mitco" tyre can be fitted only to divided, three-piece, and four-piece wheels—a charge is made for conversion—and because a very tight fit between rim and tyre is necessary assembly can be performed only by the tyre makers. Tyres are, or will be, available in sizes

Rubber-and-fabric tyre negotiating a railway line

from 4·00×8 to 14·00×24 and in four grades; wheelbarrow and agricultural implement, standard, heavy service, and extra heavy duty. The maximum speed allowed at the rated load of the tyre is 15 m.p.h.

[Reply Card No. 1275]

Marine Water Treatment Methods

ON Tuesday, October 10, at the Memorial Building, London, I. Rayleigh read his paper "A Critical Survey of Marine Water Treatment Methods" before the Institute of Marine Engineers. In the paper, which is summarised below, the author gives critical consideration to the principal methods employed to deal with the urgent problem of waterside corrosion. The first section of the paper defines some of the terms and concepts which underlie the more detailed treatment developed in the subsequent text. Other sections of the paper are concerned with the oxidation of iron, the removal of carbon dioxide and, together with consideration of the corrosion on boilers, the electrolytic effect of copper. The body of the paper is devoted to a discussion on the preferred methods of corrosion control employed in marine practice and incorporates an account of a new oxygen recorder developed by the author together with a description of his Marine Ionostat and Marine Laundry Water Economiser. In the final paragraphs an attempt is made to estimate the direction which corrosion control should take to meet the more critical demands made by ever-rising temperature and pressure conditions. Appendices discuss de-ionisation without the use of corrosive acids, record observations made on S.S. "Canberra" upon the oxygen content of the feed water, and deal with conductivity of solutions containing a multiplicity of ions.

SHORTER REPORTS *(Continued)*

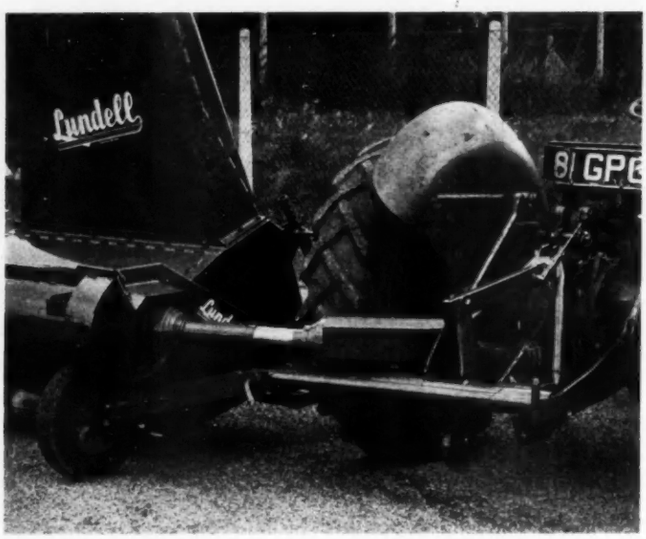
Side-Mounted Forage Harvester

We illustrate a new tractor side-mounted forage harvester which has been developed by Lundell (Great Britain) Ltd., Edenbridge, Kent. Known as the " 410," the harvester has a cutting width of 42in and combines the advantage of a fully offset machine with the manoeuvrability of a tractor mounted harvester. The drive is transmitted from the tractor through heavy duty telescopic power take-off shafts, a universal bearing and vee belt pulleys. All the drives are shielded and the belt tension is adjustable. The harvester is linked to the tractor through a hinge plate on the tow frame which is attached to the tractor lift rods and link arms. The tow frame, which carries the universal bearing to which the power shafts are connected, is adjustable to suit all makes of tractors.

The machine has three wheels, two at the rear being adjustable for height from 1in to 8in, and a leading wheel, also adjustable, which runs outside the crop and guides the harvester. The horizontal rotor carries two banks of seven flails, each bank being attached to lugs on the rotor by a rod which can be withdrawn when the flails need replacing or sharpening. The speed of the rotor is between 1500 r.p.m. and 1600 r.p.m. and the cutting height is adjustable from 1in to 8in. The high-angle swivel delivery chute is hinged, giving easy access to the flails.

The trailer which catches the silage blown from the delivery chute is directly coupled to the pick-up hook on the tow frame. The harvester itself is easily detached from the tractor by withdrawing a pin which secures the hinge plate to the tow frame, and disconnecting the power take-off shaft. In the transport position the short draw bar on the front wheel assembly of the machine is engaged to the hitch pin on the tow frame boom. The width of the machine is thereby reduced to 5ft 4in, its width when mounted in the working position being 8ft. The length of the harvester is 6ft 6in and its height 10ft 4in.

[Reply Card No. 1293]



Lundell side-mounted forage harvester with tow-frame

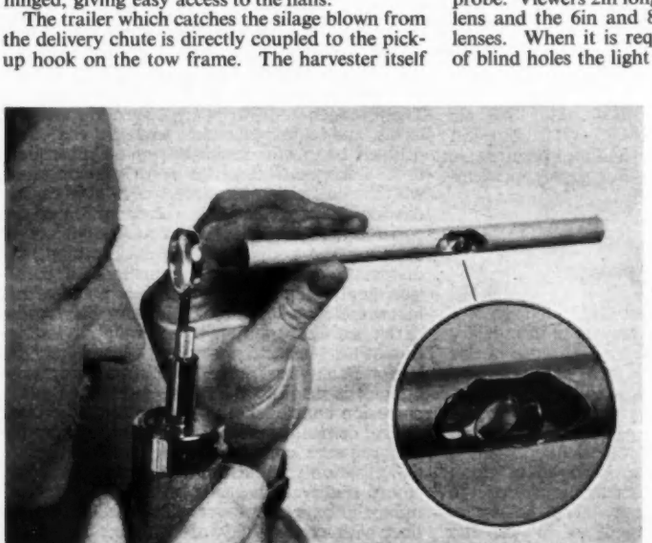
Bore-Viewing Instrument

We illustrate a useful little instrument which has been developed by P. W. Allen and Co., 253, Liverpool Road, London, N.1, for inspecting the walls of small bores in components. It comprises a battery handle, a light probe and a sleeve fitted with an elliptical mirror. The walls of the bore are illuminated by the lamp and viewed in the mirror through a magnifying lens.

These bore viewers are made in two sizes with three lengths of 2in, 6in and 8in available in each size. The smaller viewer for holes between $\frac{1}{16}$in and $\frac{9}{16}$in diameter has an $^{11}/_{64}$in wide mirror on a 0·08in diameter probe and the larger instrument for holes from $\frac{7}{16}$in to 1$\frac{1}{4}$in diameter has a $\frac{3}{8}$in wide mirror on a 0·109in diameter probe. Viewers 2in long have a ×4 magnification lens and the 6in and 8in long models have ×2 lenses. When it is required to view the bottom of blind holes the light probe is used without the sleeve. Provision is made for the fitting of a washer to the end of the sleeve to centralise the viewer in a bore.

This firm also makes a range of instruments for holes up to 30in long and of various diameters which are fitted with heads to view bores from all angles.

[Reply Card No. 1250]

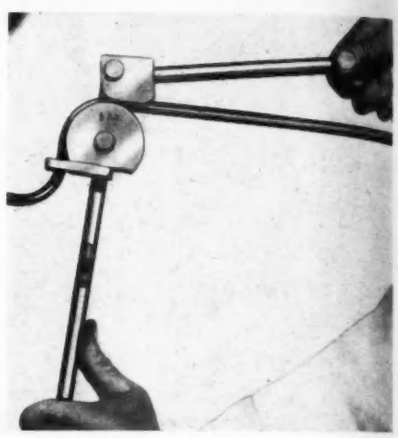


Instrument for viewing the walls of bores from $\frac{1}{16}$in to 1$\frac{1}{4}$in diameter and up to 8in deep

Small-Bore Tube Benders

We illustrate in use a small-bore tube bender typical of a new range of tools now made by Chamberlain Industries Ltd., Staffa Works, Argall Avenue, London, E.10, for use by plumbers, small-bore-heating and general engineers.

Each of the " Quikset " benders in this range is light enough to be carried in the tool bag and with them, it is stated, commercial quality bends are made without heating or filling a tube. The work can be instantly released on completion of a bend and the tools are particularly useful where tubing has been partially connected and it is undesirable to remove it for bending.



Small-bore, hand operated tube bender in use

The benders are made in eight sizes, for $\frac{1}{4}$in, $\frac{3}{8}$in, $\frac{1}{2}$in, and $\frac{3}{4}$in i.d. copper tubes to B.S.S. 659 and for $\frac{1}{4}$in, $\frac{3}{8}$in, $\frac{1}{2}$in and $\frac{5}{8}$in o.d. light gauge ferrous and non-ferrous tubes up to 16 s.w.g. thick.

[Reply Card No. 1253]

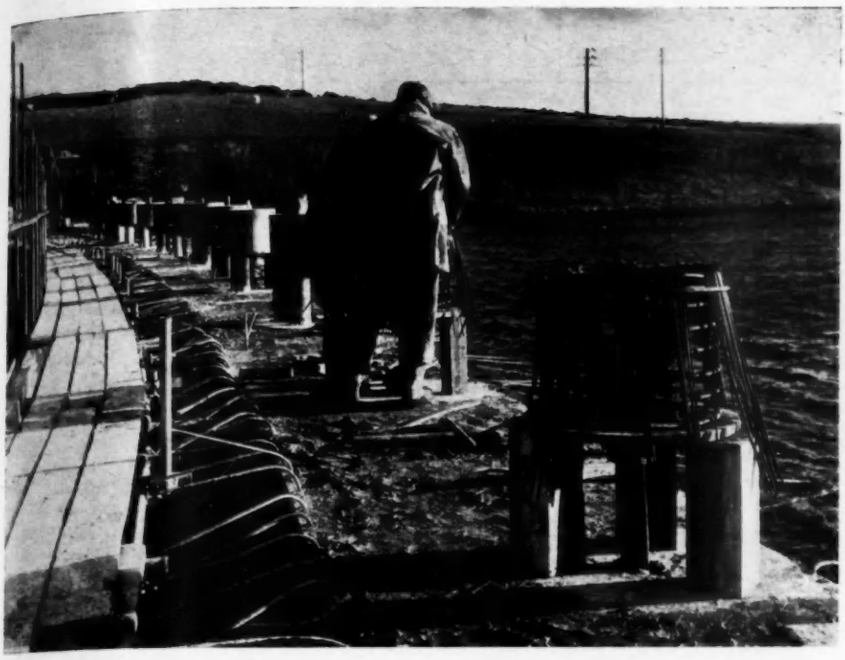
Hydraulic Tension Control

A new hydraulically operated system which can be used to control the tension of any kind of fast moving web, either paper or extensible plastic, has been developed by Hydraulic Machinery Drives Ltd., Allesley, Coventry, for use on machines with an existing hydraulic drive.

With this system the web passes over a sensing roller linked to a tension controller which has a pre-set loading and will detect any variation in web tension causing a 0·005in or more movement of a thrust pin.

The controller feeds an hydraulic signal to a servo-operated relief valve, which in turn regulates the oil pressure fed to the hydraulic motor driving the next section of the machine after the controller. The web tension is thus constantly supervised and all conditions which affect it are catered for, whether due to changes in machine speed or variations of load due to changes in reel diameter during rewind or off wind. It is stated that despite its sensitivity the use of this system does not give tension " flutter " nor does it " hunt." Servo oil pressure can be supplied by a small pump built on to the main hydraulic pump.

[Reply Card No. 1271]



Preparing cable heads for concreting. The high-tensile steel wires are being bent over the circular reinforcing cages. In the background are some completed heads supported on pedestals

Raising the Argal Dam at Falmouth

AN inauguration ceremony, at which Sir Herbert Manzoni was the guest of honour, was held at the Argal dam on October 3. The dam forms an impounding reservoir for the water supply of Falmouth, and it is claimed that it is the first dam in this country to be raised using the Coyne technique. This method involves drilling vertical holes in a gravity dam from the crest of the dam right down into the bedrock, inserting cables in the holes, anchoring them in the rock, then tensioning them from the crest of the dam. Thus an additional vertical load is applied to the dam, which is equivalent to extra weight. The extra horizontal load applied when the reservoir fills to its newly increased top water level can then still be resisted safely by the dam, the resultant thrust with the two new loads still lying within the middle third of its base.

The Coyne technique is not new, and was described in this journal in our issue of February 21, 1936, page 201. Within recent years however, it has been more widely used. The North of Scotland Hydro Electric Board's dam at Allt-na-Lairige was built in one stage, utilising this principle (see THE ENGINEER, June 17, 1955, page 851) and many other examples could be cited. Indeed, the same general principle, in a different guise, was an important structural feature of Gothic architecture. The "flying buttresses" of the later styles of Gothic carry an inclined thrust from the roof of the cathedral to free-standing stone buttresses or columns. These columns each carry an ornamental pinnacle above the level of the flying buttress. The function of the pinnacles, like the Coyne cables, was to add a vertical component to the resultant thrust.

In the case of the Argal dam, an increase of 10ft in its height has given a total storage capacity of nearly 400 m.g. One advantage of the method was that it was not necessary to lower the reservoir during the modification. Forty-seven cables were used, each of 200-ton capacity. Before they were installed the first 4ft of new masonry was constructed above the old crest level, and 4in diameter holes were drilled vertically through the dam and waterproofed. The cables were manufactured on site, each consisting of 102 high-tensile steel wires of 0·2in diameter, parallel and spaced throughout their length to ensure penetration of grout.

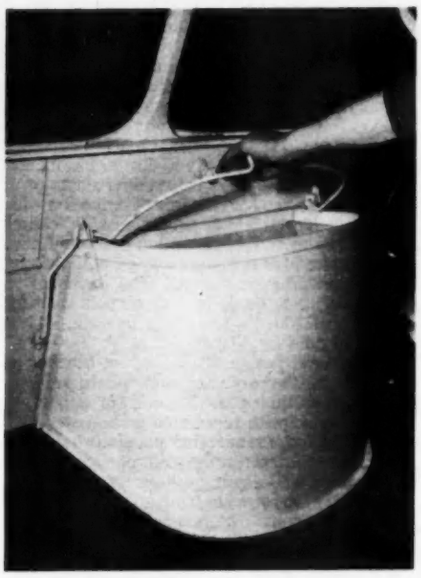
When the cables had been positioned in the holes the anchor grout was injected through a small bore steel tube, embedding every cable for 13ft from the bottom of its hole. The protruding ends of the cables were then bent over circular reinforcing cages, and the permanent concrete stressing heads cast around them. This stage of construction is shown in the illustration. The bottom anchorages were allowed three weeks to mature before stressing began, and then the temporary pedestals supporting the heads were replaced by 100-ton hydraulic jacks. Each cable was jacked several times to 200 tons as a check on its anchorage. Then the load was raised in stages to 220 tons, and finally adjusted to the design figure plus 10 per cent with allowance for the jack friction. The jacks were removed and each head supported on its permanent pedestals.

After retesting (had any cables lost stress appreciably they would have been abandoned) the final grouting for the full length of the cable was carried out. A colloidal cement grout was injected to the bottom of the hole until a suitable mixture was emerging from the top. Injection continued while the tube was withdrawn. Samples cut from experimental holes, it is claimed, have shown that in this way every wire is surrounded by grout. With the stressing operation complete, only the construction of the last 6ft of new masonry remained. The circular stressing heads were built into this second lift of concrete for permanent protection and to help in keying together the two stages.

The consulting engineers for the dam are Messrs. Rofe and Raffety, and the Falmouth borough surveyor, engineer and water engineer is Mr. B. J. Sweeney. The contractor for the dam raising work was the Cementation Company, who completed the job in ten months.

Large Door-to-Door Delivery Vehicle

THERE has been announced a series of Commer local delivery vehicles of 1½, 2, and 3-ton capacity with a cab arranged so that the driver can walk through from either side to his seat and, in the vans, the load space. As our illustration shows, a normal control chassis is used; an in-line engine is placed upright in the nose, this being, according to capacity and the operator's choice, the petrol engines of the "Hawk" or "Super Snipe," the Standard 23 C.V. diesel or the Perkins P. 4/203 diesel. The floor of the cab is raised to be level with the loading platform and to pass above the gearbox. In the case of the vans the doors open by sliding backwards, while when a chassis is supplied for body-building the cab has "jack knife" doors which force the driver's seat well away from the side of the vehicle. These doors have a small window which can be opened for giving hand signals, but otherwise all the glazing is fixed. Except for the gear lever and the wheel boxes, the floor is unobstructed; the hand-brake is a short lever under the steering wheel which moves in a plane parallel to that of the wheel and is pulled back and down to apply the brakes.



The engine is partly in the bonnet and partly in the cab: the cowling in the cab is clamped shut by over-centre latches to keep noise and smell away from the crew. Notice the short handbrake lever under the steering wheel

Among the familiar full-forward-control models of the Commer range, the 7-ton truck and tipper are now available with a Perkins "Six/354" direct injection engine inclined to 66 deg. as an alternative to the Rootes two-stroke diesel.

[Reply Card No. 1294]

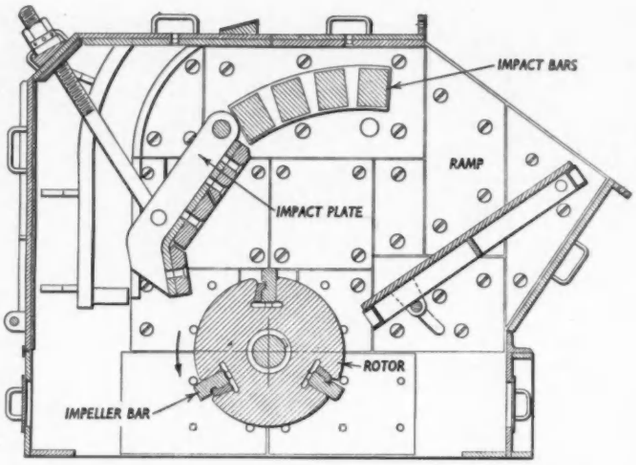
A 2-ton chassis-cab with the six-cylinder engine: models with the 2·26 litre engines have a simply curved bonnet top and the air intake flush with the headlights

SHORTER REPORTS *(Continued)*

Impact Breaker for Primary and Secondary Reduction

AN impact breaker suitable for handling a wide range of materials and which is readily adaptable for either primary or secondary reduction duties has been developed by British Jeffrey-Diamond Ltd., of Wakefield. In these machines rock is broken down solely by impact, without any "crushing", and it is stated that the resultant product shape remains constant throughout the economic life of the renewable impeller bars fitted in the rotors. Equipped for primary reduction these machines can produce from a 36in feed material a nominal 1½in aggregate in a single stage. With a machine arranged for second stage reduction, 6in to 9in material can be reduced to 1½in to ¾in aggregates or ¼in to $\frac{1}{16}$in sand. The large degree of reduction which can be achieved in a single pass is claimed appreciably to reduce operating costs and eliminate any need for a multiplicity of equipment to effect reduction in stages. The breakers are at present being made in four models with feed openings of 20in by 18in, 30in by 24in, 40in by 30in, and 50in by 40in respectively.

The general design of the impact breaker can be seen in the drawing and photograph we reproduce on this page. The body of welded steel plates is lined with renewable carbon steel wear plates, and large removable panels provide ease of access to the interior for maintenance purposes. Heavy-duty, self-aligning spherical roller bearings which carry the rotor shaft are accessibly mounted on pedestals some distance outside the body and a multi-vee rope pulley through which the drive is taken is keyed on to the end of the shaft, the use of the belts assisting to isolate the driving motor from the effects of shock imparted by large variations in feed size. The rotor is built up of welded steel segments and, according to the class of material and nature of the duties, can be supplied to take from two to six impeller bars. These bars are reversible and are locked into the rotor body by wedge inserts with means of screw adjustment, provision being made for easy bar reversal or replacement without removing the rotor from the machine. Material delivered into the feed opening gravitates down on to the rotor on a ramp, the angle of which can be easily adjusted from outside the body to suit the class of rock. Beyond the rotor on the opposite side of the body to the feed ramp there is a heavy impact plate lined with chrome steel wear plates. This impact plate is pivotally supported at the top and the distance between its lower edge and the rotor is set by the position of lock nuts on control rods which project through the main casing of the machine. It is the setting of the lower edge of this impact plate in respect to the rotor which controls the final product size. The weight of the plate maintains it in its operative position for normal duties but, in the event of an excess load being applied at its operative edge, it is free to swing back and prevent overloading of the drive or undue damage to the rotor or impeller bars.



Arrangement of impact breaker fitted with impact bars

When a machine is used for primary crushing a series of easily removable breaker bars is used in the impact zone immediately above the rotor and adjoining the top of the adjustable impact plate, allowing material of maximum feed size to pass freely into the machine. For secondary crushing purposes a second fixed impact plate is introduced to replace the reversible breaker bars.

A prolonged series of trials has been carried out on the new machines with a wide range of materials. One of these tests was concerned with pit refuse from Shawcross colliery (Wheatley limestone with inclusions) with the machine in its secondary reduction arrangement with breaker bars and having two impeller bars on its rotor. As a matter of interest we give the results obtained by the maker with the smallest impact crusher (with those of the largest machine in brackets). With a rotor speed of 850 r.p.m. (450 r.p.m.) and a drive of 25 h.p. to 30 h.p. (300 h.p. to 400 h.p.) the machine was fed with material of 12in (34in) cube maximum. The total output of 35 tons to 55 tons per hour (210 tons to 290 tons per hour) passed a 2½in mesh, 75 per cent 1in mesh and 50 per cent ½in mesh. Trials on Knottingley sandstone were also carried out and we give the maker's results in a similar way for the smallest and largest machines. With a rotor speed of 1060 r.p.m. (520 r.p.m.) and a drive of 40 h.p. (210 h.p.) the machine was fed with 12in (34in) cube material. The total output of 40 tons per hour (210 tons per hour) passed a 2in mesh, and 85 per cent a ½in mesh.

In another test, a machine reduced Tunstead limestone with a maximum feed size of 12in by 10in by 6in using various settings of the impact plate to give a product from ½in to 4in. The machine was fitted with three impeller bars and three breaker bars and its rotor driven at 1000 r.p.m. With a 4in setting 99 per cent of the produce was 4in and below and with a 1½in setting the total output was below that size—98 per cent being 1in and below. Production with the machine driven at 850 and 1200 r.p.m. closely approximated to these results.

An important part was played in the development and testing of these impact breakers by a new test installation for crushing plant which was installed by British Jeffrey-Diamond Ltd., just over a year ago. In this test-house full size machines can be installed and run under controlled conditions to determine plant efficiency, throughput, power requirements, &c., with various materials. Materials are delivered into the feed hopper of a machine under test by conveyor from a loading station at the side of the building. The product of the machine is delivered on to a second belt conveyor leading out to an adjoining screening house. This house is situated on a raised platform with delivery chutes below to allow the loading of bins or other containers with the crushed product for inspection or weighing or other checks.

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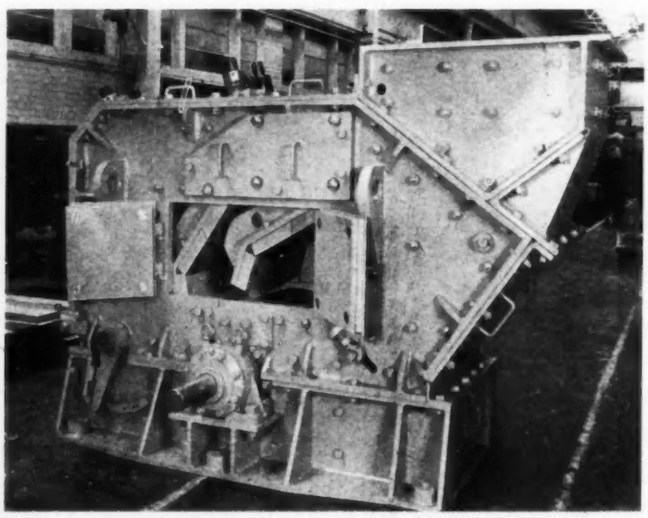


Impact breaker with its side inspection doors open to show the pivoted adjustable impact plate

Railway Research Laboratories

As part of a comprehensive scheme to reorganise and expand the Research Department of British Railways, work is about to begin on the construction of new buildings for engineering laboratories and departmental headquarters at Derby. This is another stage in the project which began with the completion last year of new chemical laboratories at Muswell Hill, London. Under the scheme the new buildings at Derby will house the combined engineering, vehicle and track-testing, metallurgy and physics divisions, and will also become the headquarters of the Director of Research, whose present office is in London. The new group of buildings has been designed by the architect of the British Transport Commission, F. F. C. Curtis, Dr.Ing., A.R.I.B.A. The site is on the north side of London Road, Derby, opposite the existing laboratories built by the former L.M.S.R. in 1931. The biggest buildings in the group will be a flat-roofed five-storey administration block housing scientists' study rooms, a library and offices, and, at the west end, a large equipment test-hall some 200ft square. The whole group of buildings will have a total floor area of about 100,000 square feet and will occupy some 85,000 square feet of ground. Construction is being undertaken by William Moss and Sons Ltd., Loughborough.

INDUSTRIAL NEWS

Iron and Steel Production

The production of steel in September was 17 per cent below that for September, 1960. Production recovered after the summer holiday period to a weekly average of 400,200 tons during September compared with 338,400 tons a week in August. The September figure represented the use of 77 per cent of the available capacity. According to the monthly production statement issued by the Iron and Steel Board, the fall in steel production during the present year has followed broadly the same course as in 1958, the last year when activity in the steel industry declined. The reduction in steel production in 1961 appears to be largely caused by a reversal of the stock increase which took place in the previous year, the Board says, as happened in 1958. In the third quarter of last year consumers' and merchants' stocks increased by 340,000 ingot tons whereas in the third quarter of this year there are indications that stocks have been reduced substantially.

Although new export business is difficult to secure, the Board says, current export deliveries are being maintained at a rate greater than in 1960. Imports of most kinds of steel are continuing to fall as commitments come to an end. Imports during August included 6000 tons of hot-rolled coil received from the U.S.S.R. for rolling into sheet and re-export. Net exports of steel, the Board states are being maintained well above the previous best figures reached in 1959.

Industrial and Export Trends

According to the results of the latest enquiry into industrial and export trends made by the Federation of British Industries, business optimism has lessened significantly. Returns from 686 respondents covering the four months June to September, indicate that although the trend of output has been slightly upward there has been a fall in orders. Most firms reported that they were working below full capacity or had more unused capacity and there has been no further increase in the labour pressure. Investment intentions show a downward trend.

The detailed results show that the rising trend of output indicated last June has continued as existing orders are fulfilled. In contrast with the upward balances reported last June however, more firms have reported a decline in the rate of new orders than an increase and more a shortening than a lengthening of order books. A lack of orders, the Federation says, has replaced a shortage of skilled labour as the main impediment to increased output.

More firms have reported a rise than a fall in stocks of raw materials, and the rise in the number reporting an increase in work in progress has continued but at a slower rate over the past four months. Rising industrial costs have again been reported by a large majority of respondents, the Federation states, and this has inevitably been reflected in the continuance of more pressure on profit margins.

Some 51 per cent of the respondents reported that they were working below full capacity as against 45 per cent in June. The apparent paradox of rising output and an increase in unused capacity is explained by the fact that industrial capacity has increased during this period.

The prospective tailing off of the investment boom is emphasised by the replies to the questions on capital expenditure. For the last year a majority of firms reported their intention to authorise less expenditure on buildings in the next twelve months, and this downward trend is accelerated this time. For the first time in two years a majority of firms report an expectation of a decline in expenditure on plant and machinery.

In contrast to the pessimism in the home market, the Federation points out, views on export prospects are closely balanced between pessimism and optimism. There seems to have been a slight decline in the rate at which new orders have been received though less marked than for the home trades but nonetheless more firms reported a rise than a fall in the level of deliveries. Finance seems to have become a slightly more important factor in exporting and delivery dates slightly less, the Federation reports, but the trends are not yet strong and meeting competitors prices continues to be the outstanding difficulty.

An analysis of overseas markets suggests that prospects are continuing to worsen in Africa and Australasia and continuing to improve in the European Free Trade Association and the European Common Market.

Safety in Shipbuilding and Ship-Repairing

A one-day conference on safety in the shipbuilding and ship-repairing industry, convened by the Minister of Labour and attended by delegates representing both employers and workers, was held in Newcastle upon Tyne on Monday this week. Addressing the conference Mr. John Hare, Minister of Labour, drew attention to the fact that in the shipbuilding and marine engineering industry in 1960 there had been forty-two accidents for every 1000 people employed, which was about twice the rate for manufacturing industry on a whole.

Three papers were read at the conference. Mr. E. J. Hill, chairman of the Shipbuilding Sub-Committee of the Confederation of Shipbuilding and Engineering Unions, reviewing safety activities in the industry, said that the new shipbuilding and ship-repairing regulations covered a wide range of hazards and the trade unions wanted those regulations to be strictly enforced. The unions in the industry would, on no account, he said, countenance the breach of the regulations, either by employers or by their own members. The shipbuilding unions, Mr. Hill went on to say, believed firmly in the need for safety committees in every British shipyard. The very existence of safety committees, meeting at regular intervals, he said, had the effect of promoting safety consciousness. It should be the job of the safety committees to analyse every accident that occurred. Only in that way, Mr. Hill added, could accident prevention policy be continuously developed and related in the most intimate fashion to the particular circumstances of each workshop and yard.

Mr. T. W. McCullough, H.M. Chief Inspector of Factories in his paper "Accidents: The Problem in Shipbuilding," pointed out that, excluding marine engineering, the industry sustained 6691 accidents in 1960, of which twenty-seven were fatal. In the shipbuilding and ship-repairing industry, he said, 11 per cent of accidents resulted from the use of hand tools. The chance of having a hand tool accident in a shipyard was twice as great as it was in industry generally. Falls accounted for 13½ per cent of accidents in the industry and the chances of injury from falling were three times as great for the shipyard worker as they were for the worker in industry generally. In the next class of accident, that of being struck by falling articles, the figure in shipyards and dry docks was 11 per cent, and in wet docks and harbours, 10 per cent. The chances of being struck by a falling article in a shipyard were 2¼ times greater than in industry generally. In shipyards and dry docks, Mr. McCullough said, 13 per cent of accidents arose from stepping on or striking against objects. In wet docks and harbours, the figure was even higher, namely 23 per cent. Throughout the industry the chance of an accident from these causes was 2½ times as great as the general industrial risk. The risk of an accident from handling goods or materials was the biggest risk of all, he said, and 23 per cent of accidents in the industry were due to that cause, the risk of such an accident being 1½ times the general industrial risk.

The third paper "Training in Safe Working Methods," was read by Mr. P. Denham Christie, executive director of Swan, Hunter and Wigham Richardson Ltd; it placed particular emphasis on the training of the younger worker.

Skelmersdale New Town

Skelmersdale, between Wigan and Ormskirk, in Lancashire, is to be the site of a New Town, the first to be designated in England and Wales for eleven years. The primary purpose of the New Town will be housing people from Merseyside, and the target population will be 80,000. Mr. Henry Brooke, Minister of Housing and Local Government, has confirmed an order designating 4,029 acres for the purpose.

The Minister's Inspector, Sir Richard Manktelow, held a public inquiry into objections to the draft order on May 31, June 1 and 2 this year. His report to the Minister, will be published shortly by H.M. Stationery Office. In his conclusions Sir Richard said that the idea of developing Skelmersdale to house Merseyside overspill had been under discussion for at least ten years with very little progress. It seemed to be accepted that Skelmersdale ought to be expanded and there appeared to be little opposition to the idea of proceeding under the New Town Act, 1946. But the bigger the suggested total population the stronger the objections became. The present proposal was the largest yet made, but on the other hand the problem of overspill was growing too. He considered that if a new town was to be based on Skelmersdale it ought to be as large as circumstances permitted so as to make a really substantial impression on the problem. He therefore thought that the urgency and scale of the housing problem ruled out the rejection of the proposed site.

PERSONAL AND BUSINESS

Appointments

MR. FRANCIS SEELY has joined the semiconductor division of Mullard Ltd. as sales manager.

MR. W. H. DIAMOND has been appointed to the board of Braithwaite and Co. Structural Ltd.

MR. G. F. EDWARDS has been appointed general manager (production) by F. W. Berk and Co. Ltd.

ASSOCIATED ELECTRICAL INDUSTRIES LTD., has appointed Mr. A. C. Main as a director of manufacturing services.

MR. D. S. GARDNER has been appointed by F. W. Berk and Co. Ltd. to succeed the late Mr. E. L. Pipe as foundry sales representative in the Midlands, South Wales and the West.

MR. R. R. DARROCH has succeeded Mr. D. C. Leathley as Commodore Chief Engineer, Royal Fleet Auxiliary Service, following Mr. Leathley's retirement on September 28.

MR. K. B. MILLER has relinquished the appointment of managing director of Miller Insulation and Engineering Ltd. but remains on the board. He has been succeeded as managing director by Mr. W. B. Macmillan.

MR. J. A. W. GILL has been appointed a director of Steele and Cowlishaw Ltd. He will retain his position as manager of the chemical machinery sales department of Baker Perkins Ltd., the parent company of Steele and Cowlishaw Ltd.

THE SOUTH WESTERN ELECTRICITY BOARD announces the appointment of Mr. Richard Piper to be its district commercial manager, Bristol South ; he succeeds Mr. C. J. R. Blackett who recently was appointed manager of the Board's Exeter district.

SIR BEN LOCKSPEISER has been appointed to the board of Cyril Adams and Co. Ltd., one of the machine tool companies in the Staveley group. He is scientific adviser to the group and is on the board of Staveley Industries Ltd., the parent company.

MR. R. G. MONKHOUSE, manager of the central engineering workshops at The United Steel Companies' Workington Iron and Steel Company branch, has been appointed works manager (Ickles) at the Steel, Peech and Tozer branch and will take up his new post on November 1.

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY announces the appointment of Mr. H. V. Disney, M.I.Mech.E., at present deputy managing director, as managing director of its engineering group to succeed Mr. J. B. W. Cunningham, M.I.Mech.E., who is resigning from January 20, 1962.

MR. JAMES COWARD, M.I.E.E., assistant generation engineer at the North of Scotland Hydro-Electric Board's Tummel Valley group of power stations, has been appointed generation engineer in charge of the Board's Conon Valley and Affric group. He succeeds Mr. J. Stuart Oliver, who has retired.

MR. R. SCHOLEY, works manager (flat products) at The United Steel Companies' Steel, Peech and Tozer branch, has assumed responsibility for the Templeborough bar mill and the 10in and 14in mills in addition to the flat products departments. His designation is now works manager (re-rolling mills).

A. A. JONES AND SHIPMAN LTD. announces new appointments in connection with the J. and S. Small tools and equipment division of its organisation. As from November 1, 1961, Mr. P. Farnsworth is appointed export and commercial sales manager, and Mr. W. Disney, manager of home sales and equipment.

MR. C. E. H. ECKERSLEY has relinquished his executive duties as sales director of Davidson and Co. Ltd., but continues his association with the company as a member of the board of directors, and in a consultative capacity. Mr. W. R. Magowan, general sales manager, has been appointed sales director.

MR. RAYMOND E. PURVES, chairman and managing director of the Clyde Industries Group in Australia, has joined the board of directors of The Fairey Company Ltd., holding company for the Fairey Group. Mr. Purves has been chairman and managing director of Fairey's Australian subsidiary company since it was formed in 1943.

SUBMARINE CABLES LTD., owned jointly by Associated Electrical Industries Ltd. and British Insulated Callender's Cables Ltd., announces that its board has been re-constituted by the appointment of three new executive directors responsible to the existing managing director, Mr. F. W. H. Shaw. They are Mr. C. L. G. Fairfield, commercial director, Mr. G. H. Foot, chief engineer, and Mr. S. J. Wilson, works director.

Business Announcements

MR. C. W. KING, M.I.C.E., chief civil engineer, British Railways Central Staff, British Transport Commission, retired on October 14.

MULLARD EQUIPMENT LTD., Crawley New Town, Sussex, states that its telephone number will be Crawley 28787 with effect from October 23.

BRITISH INSULATED CALLENDER'S CABLES LTD. announces that Sir John Dean is retiring from the board in order to devote his time to the chairmanship of Submarine Cables Ltd.

SIR HAROLD SNOW will be retiring as a deputy chairman and managing director of The British Petroleum Company Ltd. at the end of the year but will remain on the Board.

THE RAWLPLUG COMPANY LTD. has recently purchased additional freehold factory premises known as Brent Works, Colindale Avenue, Hendon, N.W.9, formerly the property of The Tilley Lamp Company Ltd.

DR. DAVID A. BELL has been appointed director of the new AMF Ltd. Research Laboratory at Blounts Court, Peppard, near Henley-on-Thames. Its main purpose will be to undertake long range research in those fields of science which relate to AMF's industrial activities.

INSLEY INDUSTRIAL SUPPLY COMPANY LTD. announces its removal to new and larger premises at Insley House, 5, Windmill Street, London, W.1, (telephone Langham 5426-8). It is also announced that the name of the Company has been abbreviated to Insley Industrial Ltd.

ALLEN WEST AND CO. LTD., Brighton, has acquired a 56,000 square foot Government-built factory at Newtownards, Co. Down. The factory—formerly occupied by Lee Guinness Ltd.—has ample room for expansion and will immediately go over to the assembly and wiring of standard Allen West contactor panels, giving continuity of employment to the skilled labour force.

ROCKWELL MACHINE TOOL COMPANY LTD., Welsh Harp, Edgware Road, London, N.W.2, is to hold a machine tool exhibition in its showrooms from November 7 to 22. At this exhibition, to be open from 10 a.m. to 5 p.m. Mondays to Fridays inclusive, about sixty production and toolroom machines of British and Continental manufacture will be demonstrated under power.

SIMMONDS AEROCESSORIES LTD., of Treforest, Glamorgan, has moved its Birmingham Midland area sales office from Lancaster House, Newall Street, to new and larger office accommodation at Herbert House, Cornwall Street. The existing Telex number 33-312 and Birmingham Central 2248-9 telephone numbers have been retained and a third telephone line, Birmingham Central 2719, has been added.

CRAVEN BROTHERS (MANCHESTER) LTD. announces that it has entered into an agreement with the John Bertram and Sons Company Ltd., of Dundas, Ontario, under which it will supply designs, specifications, and lend technical assistance to the Bertram Company, which will be free to offer for sale in Canada and the United States Craven machine tools built in its Dundas plant, or imported from England.

F. J. EDWARDS LTD., 359-361, Euston Road, London, N.W.1, has been appointed sole representatives in the United Kingdom for Ludwig Lang Tube Bending Machines. This range includes a mandrel general purpose tube bending machine with electromechanical drive, which has a capacity of up to 3in o.d. by 14 s.w.g. wall thickness ; an electro-hydraulic model, with a capacity of up to $6\frac{1}{2}$in o.d., also of the mandrel type ; and the "Robima" electro-hydraulic machine, which caters for tubes or pipes up to 10in o.d. and can also be used for bending solid bars and sections up to 16in standard profile.

THE BROCKHOUSE ORGANISATION announces that its activities in the plastics field, which are at present concerned with the manufacture of injection moulding machines, have been wholly transferred from its Penn Road, Wolverhampton premises to J. Brockhouse and Co. Ltd., Denton Works, Saxon Street, Denton, Manchester, to whom all correspondence and enquiries should be addressed. The Wolverhampton works continues to be concerned with general machining work and machine tool manufacture and rebuilding. The Group also announces that Mr. A. Boardman has taken over the joint responsibilities of technical and sales manager and that Mr. F. V. Bird has joined the company as technical sales engineer. He will operate in the Southern Region from the Organisation's London Office at 25, Hanover Square, W.1.

FERRANTI LTD. and ARON METERS LTD. announce that Ferranti has agreed to purchase Aron's electricity metering business including manufacturing tools and equipment for £440,000. At present there will be no change in the conduct of the Aron meter business, which will continue from Salisbury Road, Kilburn as hitherto. To avoid confusion, Aron proposes shortly to change the name of its Company to Astaron Electronics Ltd., thereby releasing the name "Aron Meters Ltd.," for use by a newly formed subsidiary of Ferranti. Under its new name, Aron will expedite the move to its new factory at Aylesbury where production will be supplemented by an entirely new range of products not allied to the meter industry.

HAWKER SIDDELEY AVIATION states that the first phase of the merger between Sir W. G. Armstrong Whitworth Aircraft Ltd. and Gloster Aircraft Company Ltd. has been completed. The Gloster Aircraft Company has ceased trading under that name and all the business of the two companies is now being conducted under the name of Whitworth Gloster Aircraft Ltd. The board of Whitworth Gloster Aircraft is : Sir Roy Dobson, Sir Thomas Sopwith, Mr. H. Burroughes (chairman), Mr. W. S. D. Lockwood (managing director), Mr. C. Bayly (general manager), Mr. J. T. Lidbury, Mr. S. D. Davies, Mr. F. Martin, Mr. E. D. Keen (chief engineer—aero), Mr. F. D. Stallabrass (secretary), Mr. E. W. Shambrook (financial director), Mr. H. W. Sidwell. Mr. Hugh Burroughes was previously chairman of the Gloster Aircraft Company ; Mr. E. W. Shambrook and Mr. H. W. Sidwell were also members of the Gloster Aircraft Company board. Two former members of the Armstrong Whitworth board, Mr. H. M. Woodhams (chairman and managing director) and Mr. H. R. Watson (technical director) have retired.

Contracts

THE ENGLISH ELECTRIC COMPANY LTD., has received an order from the Tanganyika Electric Supply Company for two 14,700 h.p. vertical Francis turbines and valves together with two 10·5MW generators and associated gear, valued at some £300,000, to be installed in an underground power station on the River Pangani some 40 miles from the port of Tanga, as part of the Hale Scheme, which should go into operation early in 1964.

THE GENERAL ELECTRIC COMPANY LTD. has received an order, worth nearly £70,000, for blending machines to be installed in the Athus steelworks, Belgium, of S. A. Cockerill-Ougree. The equipment is to be incorporated in an ore-blending plant and comprises a reclaiming machine ; transfer car ; and a double-hinged boom stacker. All the structural steelwork is to be fabricated in Holland but all other parts will be manufactured in this country. The consulting engineers for the entire project are John Miles and Partners (London) Ltd.

EDWIN DANKS AND CO. (OLDBURY) LTD., a subsidiary company of Babcock and Wilcox Ltd., has secured in collaboration with two American design organisations the main contract for the supply of a gasoline plant and associated well-head equipment for Tehnometal Export-Import, Yugoslavia which is acting on behalf of the Naftagas concern in that country. The plant is to produce gasoline and industrial gases from the natural gas which is found in parts of Yugoslavia. The total value of this contract is over £1,000,000 and the majority of the material will be supplied from United Kingdom sources.

THE BRUSH ELECTRICAL ENGINEERING COMPANY LTD., a member of Hawker Siddeley Industries Ltd., has received a contract from the General Post Office to supply control equipment, motors, generators, and servo equipment for the steerable aerial now under construction at the Goonhilly Downs Post Office Radio Station in Cornwall. The electronic control system depends on the generation of highly accurate positional information by optical shaft encoders. This will be compared with predetermined steering information provided by a programmed tape, and corrective signals, converted from digital to analogue form, will be supplied to the servo mechanisms. The signals resulting from this process will be fed to the motor control system, which will then cause the aerial to move to the desired position. Another Hawker Siddeley company concerned in the project is Whitworth Gloster Aircraft, whose Electronics Division is building some of the digital electronic equipment. The consulting engineer to the G.P.O. is Husband and Company, of Sheffield.

CONTINENTAL AFFAIRS

by Our Continental Editor

Electrical Installations at the Berlin Opera House

A FEW days ago the rebuilt Deutsche Oper in Berlin was inaugurated with a performance of Mozart's "Don Giovanni." Among the technical equipment of the new opera house is a modern stage lighting installation supplied by the same firm which had been responsible for the stage lighting fitted in the course of the 1935 rebuilding of the former opera house. At that time the chief electrician still had to work by means of wire ropes passing over pulleys from his box to the tapped transformers. Nowadays the same job is carried out effortlessly by means of electric controls. The control position is situated to the left of the stage and contains 240 positions, a control desk, and a programme control.

Each of the 240 circuits is controlled by means of a hand-lever or variable speed motor coupled electro-magnetically to one or other of the horizontal control shafts. When the shaft is driven by motor, the respective illumination can be varied over its full range in two to fifteen minutes. With the help of the programme store, the illumination score of four scenes can be stored and the information transferred to the control desk as often as desired and in any particular sequence.

The master control desk is duplicated in the producer's room behind the last row of the stalls. Two hundred and forty magnetic amplifiers mounted in racks in a separate room offstage control the lighting voltages, receiving their own control voltages through the levers of the control desk.

For lighting the alley of a stage like the present, the old lighting system needed incandescent lamps totalling about 160kW. Colour was obtained by means of filters placed in front of the lights, which lowered the efficiency. By using a combination of fluorescent lamps of various colours, the total power can be reduced to 8kW, i.e. one-twentieth of that formerly necessary. In addition, the colour of the light now remains unaltered over the whole range of intensities. The amount of heat given off is less, and the life of the lamps is greatly increased. A further advantage, it is stated, is the diffuseness of the light. A total of fifty-two horizontal fittings, each for three fluorescent lamps, has been installed. A transistorised control gives a range in illumination of 1 : 60,000. Some 6·3 km multicore stage cables have been laid, equivalent to 22km of single-core cable which, however, would be much more bulky. For vertically adjustable fittings, flat stage cables totalling 300m were laid. Over 600 two-pole socket outlets with earth contact were installed for the various floodlights and spots.

Behind the portals of the stage there is on each side a stage manager's control desk, the two desks being connected in parallel. From here communications extend to the stage hands, the electricians at the lighting control desk, the artists' changing rooms, the conductor's desk, the prompter, and the producer's room. From this place the bell signal for the start of the performance is given, after control lamps have indicated that conductor, orchestra, stage hands and electricians are at their posts and ready. Buzzer calls to go on are made by means of small illuminated push-buttons to the changing-rooms of the various artists who cancel the call by pressing a button in turn, which makes a signal light up in the reply button on the stage-manager's desk to show the particular artist is ready to go on stage. Both lamps are extinguished when the reply button is momentarily depressed. In the same way, calls may be made to the choir or ballet ; if several actors have to appear together, the call may be made by a common group button, but individual cancellations are still required. In addition it is possible for the stage manager to give instructions or information over a loudspeaker system covering eighty-four rooms. This also enables the actors to hear in their changing rooms what is going on on the stage.

The stage manager can also speak by telephone with the electricians, stage-hands and others. An induction loop enables electricians and stage-hands to hear messages without the need for a wired connection. A separate small telephone system aids the work of the costume and make-up department.

Closed-circuit television enables the stage manager and producer to see the conductor throughout the performance. Additional television sets at the back and sides of the stage give the choir a view of the conductor.

Special acoustic effects are controlled from the stage manager's desk. For live broadcasts there are ten microphone connections provided. An inductive installation enables deaf people wearing hearing aids fitted with induction coils to follow the performance from any part of the house.

As in every theatre, fire alarms form an important adjunct of the equipment. A total of 189 ionisation alarms have been installed. These are mounted on the ceiling and react at once to the presence of smoke or combustion products. In addition, conventional manual alarms are available throughout the building. Their circuits include check points which must be operated by the watchmen on their rounds with a key, causing the location and time of the check to be centrally registered. Mention may also be made of the centrally-controlled system of clocks and the telephone installation with about 100 extensions and ten post office lines.

The installations described here were carried out by Siemens-Schuckertwerke A.G., Berlin and Erlangen, and Siemens & Halske A.G., Berlin and Munich.

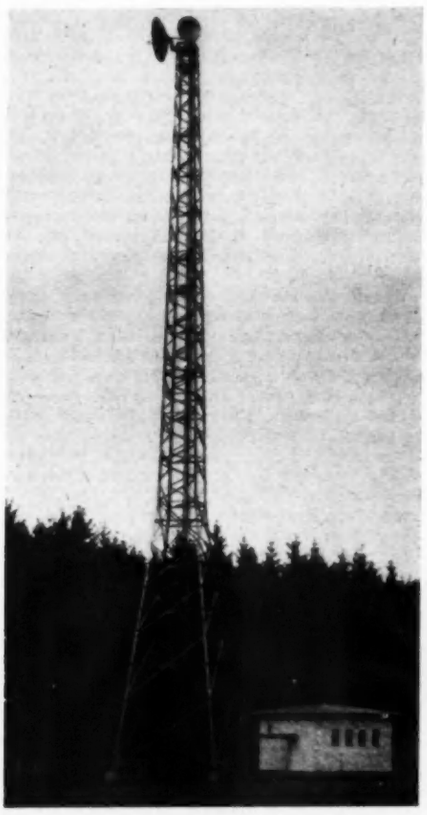
Lead Development in Europe

The formation of the European Lead Development Committee, to co-ordinate and expand promotional work throughout Europe is announced following meetings in Rome between representatives of the French, German, Italian, Spanish and United Kingdom lead development associations and the Belgian and Swedish lead producers. The Lead Development Association, London, will be responsible for the secretarial work of the new committee under the guidance of a steering group comprising France, Germany, Italy and the United Kingdom. An international conference on lead is to be held in London from May 22 to 25, 1962. Technical aspects of many lead uses will be described in special reports shortly to be issued. A European lead bulletin is to be published in French, German, Italian and English.

The consumption of lead in all forms in Europe has risen in the last four years by about 120,000 tons (11 per cent) to 1,200,000 metric tons in 1960. Preliminary figures for the first half of 1961, prepared by the Committee, show that the growth is continuing for Europe as a whole despite some levelling off in the United Kingdom, where consumption per capita is the highest in the world.

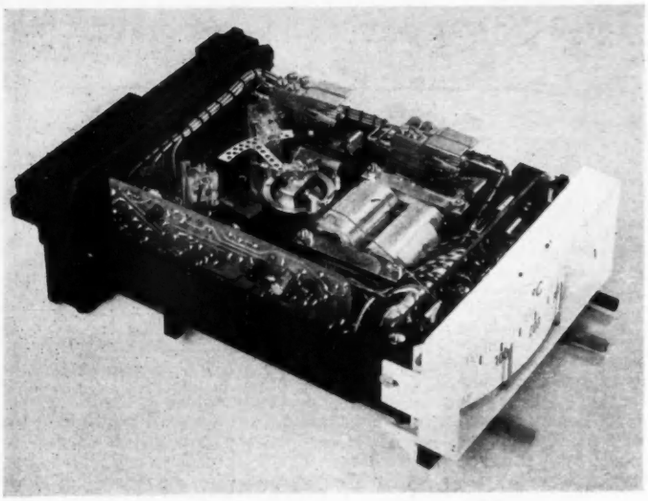
Radio Telephone Links in Power Distribution Systems

With the present extensive systems for the transmission and distribution of electric energy, efficient telecommunications lead to improved surveillance, greater reliability, and more economic exploitation. Considerations of this nature have led the Bayernwerk power company, one of the largest electricity supply undertakings in Germany, to adopt far-reaching measures in the telecommunications field. In this, the company had the assistance of Siemens & Halske A.G., Berlin–Munich, which supplied radio equipment capable of transmitting simultaneously up to 120 conversations, or alternatively, a large number of teleprinter and telemetering signals. Our illustration shows the fully automatic beacon at Sünzhausen/Hallertau which forms part of the first Bayernwerk radio link connecting Munich–Karlsfeld with Stein near Nuremburg. Altogether, three relay stations are required with distances of up to 55km between them. Because of the narrowness of the pencil emitted by the parabolic aerials, the concentration of energy is such that a transmitter of only 1W is sufficient to bridge this distance.



Fully automatic radio telephone relay requiring no personnel for its operation

CONTINENTAL AFFAIRS *(Continued)*



Indicating instrument with contactless electronic operation. The casing is removed, showing the etched transistorised circuit, the metal vane attached to the moving coil system moving in the gap between an oscillatory and feedback coil, and the 60W power relays

Electronic Indicating Instrument

In addition to showing a reading, panel instruments often set going an optical or acoustic alert if a certain value of the particular variable is recorded, or else they actuate suitable controls directly.

This control function of the instrument should not affect the readings to which it should correspond accurately and without time lag. Mechanical contacts only partially fulfil these requirements, it is claimed, while certain other solutions such as bolometers or photoelectric systems are often too expensive to instal.

An instrument which, it is stated, provides the answer, has been put on the market by Siemens & Halske A.G., Berlin-Munich.

The equipment employs transistors and etched circuits and in consequence is small, requires but little power to operate, is reliable and always ready to be put into operation.

Two small ferrite-cored high frequency coils are arranged opposite each other, and form the oscillatory and feedback coils of a transistorised oscillator. A metal vane rigidly mounted on the pointer moves into the gap as the designated limit is reached and interrupts the high-frequency oscillation so that the output voltage falls to zero. The fact that the connected alarm system responds to zero voltage makes the arrangement "fail safe" as a malfunction of the electronic instrument will also give the alarm signal.

The moving vane is a light piece of sheet metal which does not noticeably increase the inertia of the moving system. A high output wattage is obtained by using a transistorised flip-flop to control a power transistor. This is adequate to actuate a 60W power relay.

Our illustration shows the instrument with its cover removed. The front measures only 144mm by 72mm. A maximum and minimum contact can be fitted, the position of which can be adjusted by means of two red markers on the scale which can be set at a minimum distance of about 3 per cent of the full scale value. In addition to the moving coil model, moving iron, quotient and electrodynamic instruments are available. Where necessary, an external trans-transformer must be used.

Evacuated Sealing Strip

For the glazing and construction joints of Stockholm's new Radio and Television Centre over 380,000ft of "Efab" evacuated seals were employed, resulting, it is claimed, in a saving of more than 10,000 working hours. The building measures 640ft in length and 72ft in height. It is tee-shaped in plan, and its five glass façades have a combined length of 1431ft, and a total area of 103,000 square feet. There are also three concrete gable walls with a surface area of 14,000 square feet, each wall consisting of 108 concrete blocks. The total number of windows in the building is 2400.

To seal the concrete blocks, seals 11mm to 20mm wide were used. On the curtain wall panelling the seals have to take structural movements up to 3mm and dimensional variations in the panels from 6mm to 12mm. The exterior panelling is of aluminium backed with special timber. For the internal joints between the wall elements the tolerance was from 6mm to 20mm. Therefore seals in three sizes were employed.

The seals are hollow, extruded sections made of "Neoprene" synthetic rubber. They are supplied with the centre evacuated, which collapses the section so that the strip can be freely inserted in the joint. By breaking the vacuum and admitting air, the seal is allowed to expand, forming a tight joint which does not require caulking or cementing.

On the outside of the building, the sealing is installed as continuous strip on the vertical joints, while in horizontal joints where the elements are not provided with drainage, the seals are fitted in suitable lengths and left open, allowing moisture to drain off. Corners to match the glazing are also supplied and are fitted at the same time as the glass itself. The maker is Aktiebolaget Aldo, Vanadisvägen 24, Stockholm Va (United Kingdom agent: Machinery (Continental) Ltd., 42, Park Street, London, W.1).

High-Frequency Automatic Screwdriver

For the assembly of parts by means of cheese-head or lenticular screws of metric sizes M 1·4 to M 4, Allgemeine Elektricitäts-Gesellschaft, (A.E.G.), Berlin-Frankfurt/Main, has put on the market a high-frequency automatic screwdriver. By contrast with existing stationary equipment, the device is portable. This, it is claimed, facilitates the insertion of screws in large and unwieldy workpieces. Our illustration shows the equipment which here for convenience is suspended from a stand.

It comprises a vibratory conveyor which is mounted concentrically with the motor casing. The electric motor is a three-phase, 42V machine supplied at 300 c/s by a rotary frequency converter. Its simple construction (it has no commutator, brushes, or rotor winding) and high specific output (due to a speed of 18,000 r.p.m.) make it particularly suitable for this application.

The vibratory conveyor is operated by single-phase current of 50 c/s. The screws rise along a spiral track inside the container and on reaching the rim, slide downwards one by one along a slotted track into a guide socket below the blade of the screwdriver, where they are retained by a spring. By varying the amplitude of the vibratory conveyor, the rate of feed of the screws can be adjusted.

The guide socket is then positioned above a tapped hole in the workpiece and the machine pushed downwards by its hand grip. This first

High-frequency automatic screwdriver

lets in the clutch of the screwdriver, after which the pressure of the blade upon the screw releases the retaining spring and frees the screw which by further advancing the driver is made to engage with the tapping and finally driven home. When this stage is reached the clutch automatically disengages. Upon lifting the screwdriver, a new screw drops into position in the guide socket. Up to twelve automatic screwdrivers can be operated by a 1kVA frequency converter.

Testing of Swiss Watches

On September 1 this year, compulsory technical testing of the quality of Swiss watches was introduced for all watches produced by manufacturers affiliated to the Swiss Federation of Associations of Watch Manufacturers. The experience of just over a year in this field was sufficient to confirm the effectiveness of the testing centres, which had been working on an optional basis until the end of August. By then, 1,500,000 watches had been submitted to the twelve testing centres situated in the different watchmaking districts and employing a total of some forty experts. It is stated that, thanks to the technical advice given to manufacturers by these centres, the number of those whose products were not up to standard has greatly decreased, amounting to only 8 per cent last June.

Starter Switch

The quietness of modern car engines can on occasion mislead even an experienced driver into actuating the starter twice with resultant danger of damage to the gearing. A special starter switch produced by Robert Bosch G.m.b.H., Stuttgart, makes it impossible to operate the starter while the engine is running. Only by switching off is the interlock released so that the starter motor can again be operated.

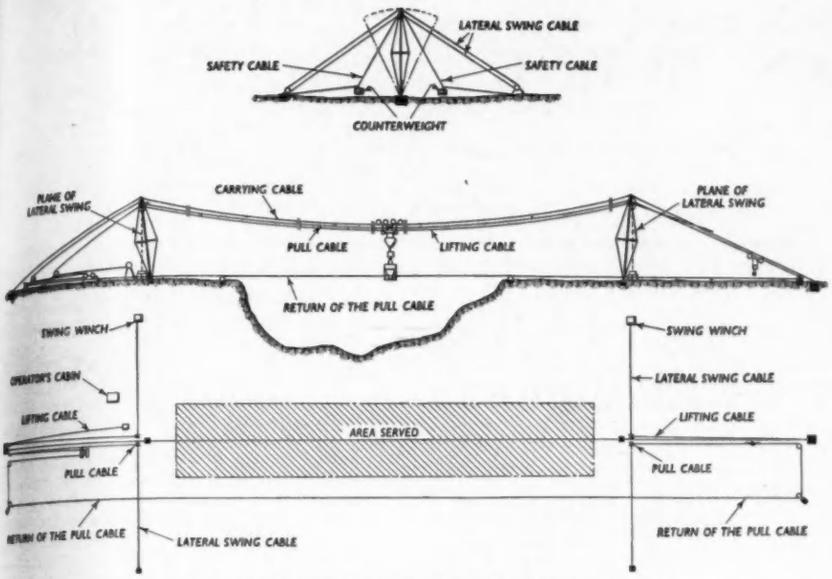


Fig. 1—Arrangement of cable crane with tilting masts

Cable Crane with Tilting Masts

In our issue of November 4, 1955, page 667, we described the Cruciani system of centering, which is used chiefly in the construction of concrete arch bridges. For the convenient erection of large-span centering arches of this kind the firm of Cruciani has developed a cable crane which incorporates a pair of masts which can be tilted and in this way can cover an area on either side of the line of the support cable. Our illustration (Fig. 1) indicates the principle.

The swinging masts or "falcons" consist of tubular struts braced by external wire stays. Simple elements of this kind can be combined to form masts of up to 20m length, as shown in Fig 2(*a*), while even higher masts can be built using additional cross pieces and stays as shown in Fig. 2 (*b*). Eventually, conditions of stability and resonance connected with the period of rotation of the pulleys have to be taken into account.

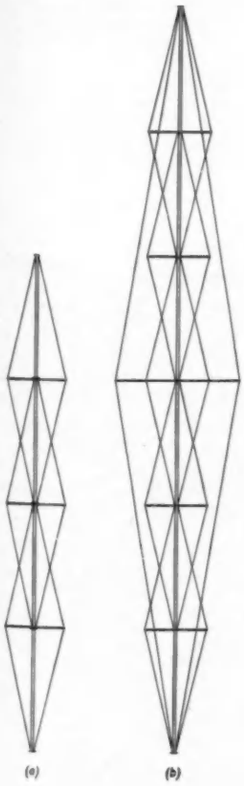


Fig. 2—Principle of extending masts, *(a)* up to 20 metres *(b)* above 20 metres

The system, it is claimed, has the advantage of lightness. For example, a 2-ton capacity crane of 400m span, with masts 32m high, can be carried on a lorry with trailer.

The lateral tilting movement of the masts is produced by means of a double-drum winch which actuates the transverse guy rope. At the the far anchorage, the rope is reversed over a pulley and passed back over another pulley at the top of the mast to the second drum of the winch.

In order to decrease the stresses in the cables, additional safety cables are fitted. These have counterweights attached which are lifted off the ground on the side from which the mast moves away, thereby opposing the tilt.

As the top of the mast describes a circle, while the locus of the point of attachment of the tilting cable is an ellipse, there is a discrepancy tending to give rise to an uncontrolled swing which can be objectionable, particularly on sloping ground. This effect may be reduced by passing the return cable along the ground instead of back over the mast (if the situation permits) or by varying the diameters of the two drums in a certain ratio. Moreover, the anchorage at the top of the slope may be brought nearer to the foot of the mast, until the angles which the cables subtend with the vertical are the same on both sides, in which case the ellipse will be tangential to the circle described by the top of the mast.

For cases where a greater width of ground (400m or more) has to be covered, the system has been extended to use four support points which may be masts or, as is sometimes possible on mountain sites, anchorages in the ground. The longitudinal cables then carry a transverse travelling cable supporting the crab.

The British agent for Cruciani is Approved Inventions, Ltd., 211–15, High Street, Orpington, Kent.

Conrad Matschoss Competition, 1962

Since 1953, the Verein Deutscher Ingenieure (VDI) has held a biennial literary competition for which papers and articles of a technological-historical character are eligible. The competition is named after Professor Conrad Matschoss who for many years was director of the VDI and who was much interested in questions concerning the history of technology.

Manuscripts (in German and previously unpublished) must be submitted before July 1, 1962, and may deal either with new technological-historical findings based on the author's researches, or with the author's own recollections of important personalities or events. Full information may be obtained from the Verein Deutscher Ingenieure, Düsseldorf 10, P.O. Box 10250.

Observatory Dome of Polyester Resin

A large hemispherical dome made of glass-fibre reinforced polyester resin has been produced by N.V. Werkspoor, Utrecht, for the astronomical observatory of the University of Leyden, and was recently installed there. The dome has a diameter of 33ft, and was built up from eighteen prefabricated sections which were assembled on site on a steel frame made of tee-sections. Including the frame, the weight of the structure is 5000 kg; because of the low weight of the plastic, the amount of steel could be kept to a minimum. Although in the present case a steel frame has been found necessary in view of the comparatively large size of the structure, it is stated that smaller domes can quite readily be designed to be self-supporting. The shell sections were laid-up in a single mould and consist of several layers of glass-fibre mats and one layer reinforced with glass fabric. After lining the mould with a gel coat, several layers with mat reinforcement are placed, followed by a glass-fabric reinforced layer on the inside. This gives a better degree of smoothness on the outside than if the fabric reinforcement had been placed directly on the gel coat. After the final assembly a patching compound was used to fill the joints between the dome parts. As the work was being carried out in winter, this compound had to have a short curing time even in cold weather.

The dome is provided with a vertical open strip through which the observations are made. A door, also made of polyester resin, serves to close this opening when not in use. During observations the dome is rotated so as to allow tracking of any heavenly object by the telescope.

In order to keep the dome cool on sunny days, a special aluminium pigment was used in the gel coat. Provision was also made to ensure uniform humidity of the air, by spraying the inside with asbestos fibre which absorbs water when the air is damp and transfers it again when the air is dry. Maintenance costs are stated to be very low as there is no need to paint the dome which is resistant to the weather and to attack by insects and fungi. The polyester resin was produced by Kunstharsfabriek Synthese N.V. (distributor: F. W. Berk and Co. Ltd., Berk House, 8, Baker Street, London, W.1.).

A 33ft diameter observatory dome, consisting of a glass-fibre reinforced shell supported on a steel frame, being placed in position by a crane. The complete dome weighs 5000 kg

THE AMERICAN SCENE

By Our American Editor

Advanced Laboratory for Studying Radioactive Elements in Illinois

One of the the world's most advanced laboratories for studying highly radioactive chemical elements that are made by man is now under construction at the Argonne National Laboratory of the U.S. Atomic Energy Commission, at Argonne, Illinois. The building is a three storey wing of cave-like shielded cells and of laboratories now being added to the Argonne chemistry building. The wing will serve as a centre for fundamental research with man-made elements that are heavier than uranium. Construction of the scheme began in May and is expected to be complete in the latter part of 1962.

AN advanced laboratory for the study of radioactive chemical elements is being constructed at the Argonne National Laboratory, at Argonne, Illinois. The new laboratory structure is being built of reinforced concrete with iron ore mixed into the concrete in areas where highly radioactive materials will be handled. This ore aggregate will add to the effectiveness of the concrete as radiation shielding.

The wing will be approximately 95ft wide and 320ft long, and the total floor area will be almost 64,000 square feet. Shielded cells at the west end of the wing will contain elaborate equipment for performing chemical experiments by remote control. These cells will occupy the entire end of the building and will be equipped with radio-controlled carts or "mules" for carrying radioactive specimens and experimental apparatus.

Typical of the elements that scientists will be handling in these cells is californium (element number 98), discovered in 1950 at the University of California. Like other radioactive materials, californium decays. However, this man-made element decays by spontaneous fission as well as by releasing such forms of radiation as alpha and beta particles and gamma rays.

Hot Cells

The hot cells for handling radioactive materials will be on two floor levels. On the lower level there will be four cells each shielded against one million curies of gamma radiation as well as one trillion fission neutrons per second. Each of the four cells will be 16ft wide, 14ft deep, and 12ft 3in high, and the walls of the cells will be 4ft thick. They will be of concrete containing magnetite iron ore to a height of 8ft and of ordinary concrete above that level.

Scientists working in the new laboratory will view their experiments through windows that are as thick as the walls of the hot cells. These will be composed of zinc bromide solution, a heavy liquid that shields against radiation, between plates of a special glass that will not discolour under radiation bombardment. Forty windows will be built into the complex of cells. In the cells where extremely radioactive materials will be handled, the windows will each have an extra slab of high-density glass to protect against decomposition of the zinc bromide solution.

Many of the experiments in the laboratory will use materials that emit alpha particles. These alpha-emitting materials are highly toxic if inhaled, ingested, or introduced into the body through breaks in the skin. In order to contain the alpha emitters, these experiments will be performed in sealed boxes behind the walls of the hot cells. The boxes are designed so that they can be dismantled and disposed of by remote control without allowing the radioactive contamination to be spread beyond the special cell where this work will be done.

In addition to the cells for handling highly radioactive substances, the new wing of the chemistry building will have laboratories for research with materials that do not emit large amounts of penetrating gamma or neutron radiation, but do contain large amounts of the alpha emitters. An isotope separator will also be housed in the wing. This instrument will be used to separate small quantities of the heavy elements into their isotopes. All these laboratories will be connected by two parallel corridors, one to be used for transporting materials that might be radioactive.

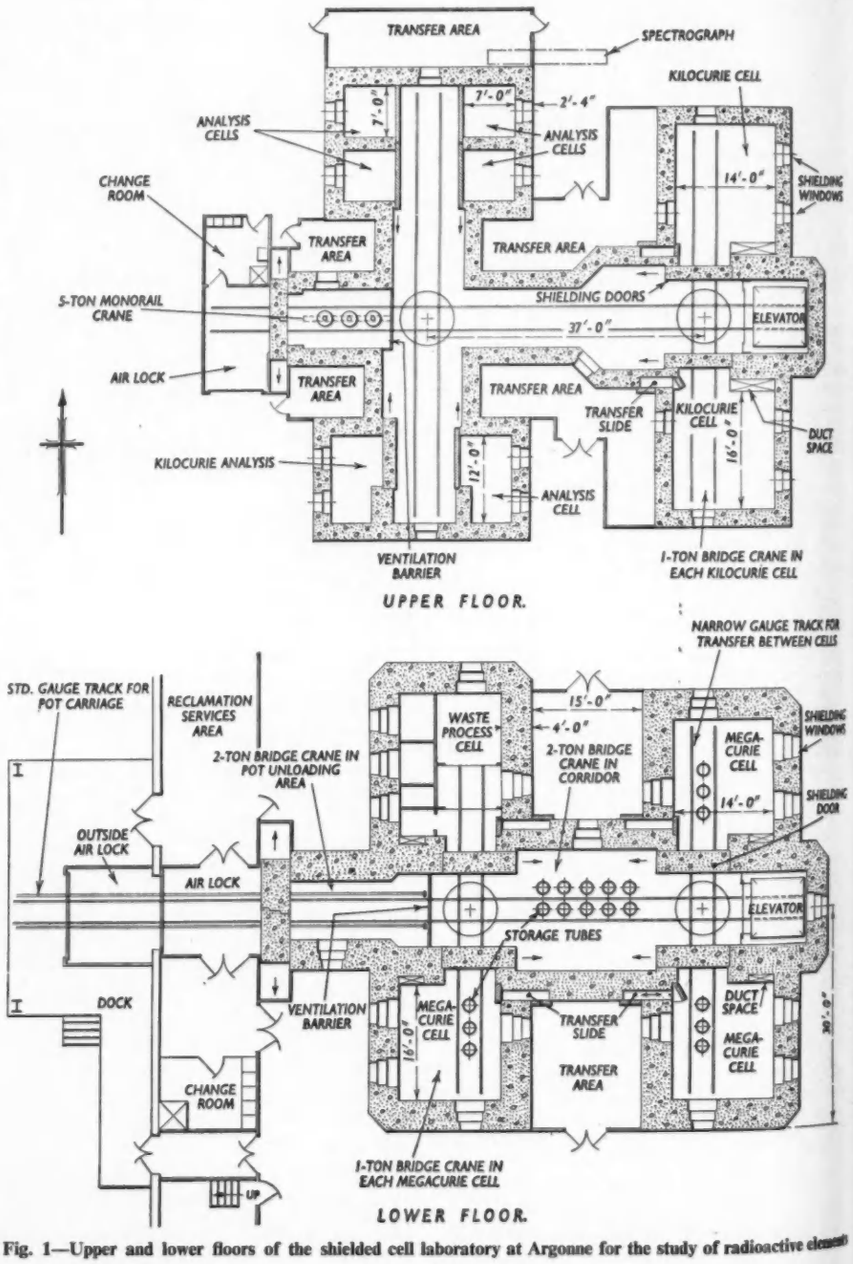


Fig. 1—Upper and lower floors of the shielded cell laboratory at Argonne for the study of radioactive elements

Handling Equipment

For most of their experiments in the new laboratory, the scientists and technicians will use standard Model-8 "Master-Slave" manipulators. These manipulators were developed at Argonne and provide a mechanical means of duplicating almost all motions of the human hand and arm behind heavily-shielded walls. Each cell will have one or more sets of these manipulators. Much of the work that will be done in the cells will be in containment boxes designed to prevent the spread of highly toxic radioactive contamination from chemical processing operations. The containment boxes will resemble small houses with gabled roofs. They will be 6ft wide, 4ft deep, and 6ft high at a centre peak. The master-slave manipulators will enter the boxes through flexible sleeves on each side of this centre peak, allowing them to handle objects within the boxes without becoming contaminated. When an experiment in one of these boxes is completed, the box and experimental apparatus can be dismantled by remote control and packaged in 30 gallon waste drums for transfer to underground waste storage vaults. This operation will be performed in a special cell designed and equipped to package contaminated wastes.

A rail system has been incorporated as part of the hot cell design so that containment boxes, radioactive materials, and experimental equipment can be moved by remote control from cell to cell. The rails will run in straight lines with externally-operated turn-tables at intersections. Low, battery-operated flat cars or "mules" will be used to carry boxes and materials throughout the cave complex. These cars will be controlled by radio signals to eliminate fouling of cables and to allow them to move freely between floor levels on a lift.

Each cell, during the course of chemical processing, will require a remotely-controlled handling device to serve the containment boxes and to assist the master-slave manipulators. This device, which looks very much like a human arm, is called a "hinged arm polar manipulator." Three of these manipulators will be installed in the new laboratory. Each will be mounted on a support column that will enable the hand of the manipulator to reach objects 11ft high and 9ft in any direction from the central column. The hinged arm polar manipulator can handle objects weighing 25 lb yet is gentle enough to handle laboratory glassware. To obtain added mobility, the entire manipulator assembly can be mounted on one of the radio-controlled flat cars.

Production of Heavy Elements

In man's effort to produce elements that are heavier than uranium, the first of these, neptunium (element 93) was obtained in 1939. Beyond neptunium is plutonium (element 94), which was discovered in 1940. Since that time, nine more heavy elements have been obtained, bringing the total to 103 natural and man-made elements.

Plutonium is by far the most useful of these transuranic elements. It is the only one that is available in large enough quantities to be separated and purified as the end product of a manufacturing process. First employed in nuclear weapons, it now can be used to create power in nuclear reactors. Several American laboratories are co-operating in a programme to secure greater quantities of man-made elements heavier than plutonium so as to learn more about their properties. The new "hot laboratory" facility being constructed at the Argonne National Laboratory will process many of the transplutonium elements produced in the United States.

Most of the man-made elements so far discovered were first built up from atoms in the targets of charged particle accelerators. However, this method produces scarcely enough of an element for a chemist to determine its properties. To build up greater quantities of most of these materials, nuclear reactors must be employed. The starting point for making all heavy elements in a nuclear reactor is uranium–238, the most common isotope of uranium. Typical of what happens, over a period of time, is the reaction which produces plutonium from uranium–238 raw material. This occurs in a reactor when atoms of uranium-238 capture neutrons and first form the isotope uranium–239, which has a half-life of twenty-three minutes. Atoms of uranium–239 emit beta particles, decaying to neptunium–239 which has a half-life of 2·3 days. The neptunium isotope subsequently beta decays to plutonium–239, the useful isotope of plutonium, which has a half-life of 24,400 years. The end result is an isotope of a new element which has an atomic number two steps higher than the original element and is one unit heavier in mass than before. The starting element captures neutrons until it becomes a beta-unstable isotope of a new element. Beta decay then gives the nuclei the added positive charges to become nuclei of the next higher element.

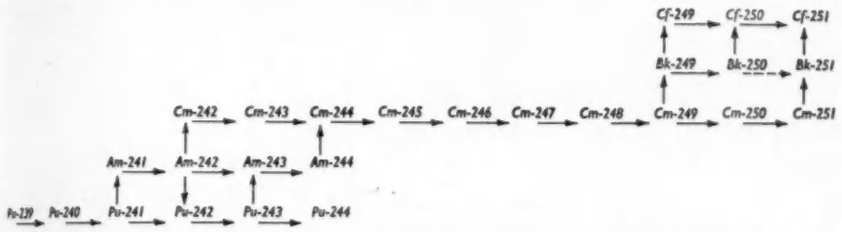


Fig. 2—Build-up of heavy elements by neutron capture, from plutonium to californium

Next, the plutonium–239 can be used to make still heavier elements. For this it is necessary to have a reactor that produces many neutrons per unit volume—a high-flux reactor. Reactors at the American Hanford atomic works and the Canadian atomic energy laboratory at Chalk River first were used for this purpose. In 1952 the Materials Testing Reactor (M.T.R.) at the Atomic Energy Commission's National Reactor Testing Station in central Idaho was completed. Since that time, this reactor has been employed for most of the heavy element production work.

The M.T.R. programme was initiated by Studier and Fields of the Argonne Chemistry Division. They fabricated several five- and ten-per-cent plutonium-aluminium alloy "napkin rings" for M.T.R. irradiation. A few of these rings were in the reactor until just recently, after undergoing more than six years of irradiation. The bulk have been processed at Argonne and other A.E.C. laboratories. These rings have yielded about 200 milligrammes of curium–244 (element 96), 75 milligrammes of americium–243 (element 95), and tiny amounts of isotopes of berkelium and californium (elements 97 and 98). Because too much heat from fissioning plutonium would create hot spots in the reactor, the M.T.R. "napkin rings" could carry only about 350 milligrammes of plutonium each.

After solving heat removal problems, the scientists next placed a rod containing 78 grammes of plutonium in the reactor. After two years of irradiation, the rod was chemically processed at Argonne. It yielded approximately a gramme of americium-243, half a gramme of curium-244, and six grammes of the isotope plutonium-242 — the largest quantities of these heavy isotopes ever prepared in America. These materials are being processed for re-irradiation in the Idaho reactor. In approximately three years these samples should yield about one thousandth of a gramme each of berkelium and californium and a lesser amount of einsteinium (element 99).

Plutonium-242 is a particularly valuable isotope in this build-up process, for by starting with it instead of plutonium-239, one can drastically reduce the amount of material that first must be irradiated. After a plutonium sample has been in a reactor for about a year, the highly fissionable isotopes plutonium–239 and –241 are essentially gone. In their places are fission products, which must be removed, and plutonium–242. This plutonium–242 then can be isolated and reinserted into a reactor. The material resulting from the second irradiation is then manageable on a laboratory scale, since much of the bulk of fission products is eliminated.

The new hot laboratory will be employed in conjunction with a new, ambitious programme to secure greater quantities of the heavy elements. Twelve kilogrammes of plutonium–239 were inserted into a reactor at the A.E.C. Savannah River ordnance plant in 1959. By 1963 or 1964 this programme should produce relatively large quantities of plutonium–242, as well as americium–243 and curium–244, as feed material for further irradiations. These irradiations will take place in the M.T.R. in Idaho and in a new special High Flux Isotope Reactor at the Oak Ridge National Laboratory. This should lead to the production of much greater quantities of berkelium and californium than previously were available. With relatively large quantities of very heavy isotopes, it should be then possible to synthesise elements above 103, the heaviest element discovered to date.

Build-up by Neutron Capture

The accompanying illustration shows the build-up from plutonium, through americium, curium, and berkelium, to californium. Plutonium–239 first forms the relatively long-lived alpha emitter plutonium–240, which captures neutrons to form the beta-emitting plutonium–241. The build-up path at this point, however, does not transfer over to americium, as might be supposed. This is because plutonium–241 has a thirteen-year half-life, and this is too long for much decay to occur under reactor conditions. However, plutonium–241 has a high probability of capturing neutrons to form plutonium–242, and plutonium–241 has also a high probability of fissioning under reactor conditions. These two facts mean that, under M.T.R. conditions, about half of the plutonium–241 will be destroyed in two weeks; this isotope never will be available in high enough concentrations to form much americium. Much of the plutonium–241 will be lost as fission products, with the bulk of the balance going to plutonium–242.

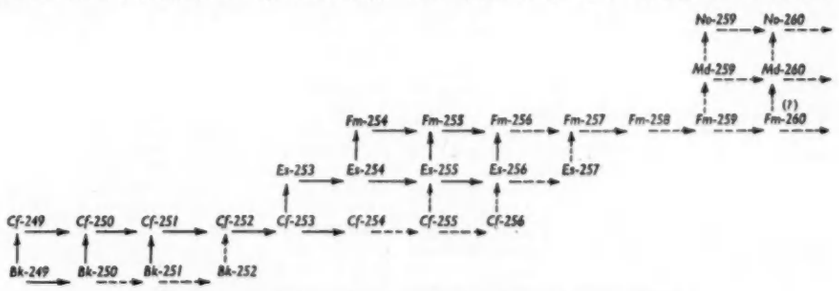


Fig. 3—Build-up path in a nuclear reactor, from berkelium to nobelium

Plutonium–242 is a long-lived isotope, so that plutonium–243 readily can be formed from it by neutron capture. Plutonium–243 has a five-hour half-life, so that it quickly becomes converted to

THE AMERICAN SCENE *(continued)*

americium–243 by beta decay. The 243 point thus becomes the true " cross-over " in going up the chain. The americium–243 is then converted to americium -244 by further neutron bombardment. This isotope is a beta emitter with a short half-life, so that it readily decays, crossing over to the next heavier element—curium. At this point, the americium fraction of the material being irradiated is essentially all composed of the isotope Am–243, and the curium fraction is essentially all made up of the isotope Cm–244. Not enough Am–241 was ever formed in the reactor to act as a source material for the formation of significant quantities of the isotope Cm–242.

Further steps of the build-up path in a nuclear reactor are illustrated herewith. As the process goes on, there are a number of obstacles to obtaining large yields of the desired heavier elements. Half lives become shorter as heavier isotopes are built. Many of the heavy isotopes fission upon being bombarded by neutrons, and some of them fission spontaneously.

To date, the heaviest element found in reactor-irradiated plutonium is fermium, element 100. Elements 101 and 102, mendelevium and nobelium, have been reported only in accelerator-bombarded materials. Element 103 recently was discovered in an accelerator bombardment. The heaviest reactor-produced isotope in the californium fraction has been Cf–254, and the heaviest in the einsteinium and fermium fractions have been E–256 and Fm–256. Build-up beyond these masses becomes very difficult due to a combination of short half-lives and low probability of capturing neutrons.

With the construction of a nuclear reactor having much higher flux than the M.T.R., it should be possible to build up past fermium–256 to fermium–257. This must be done quickly because fermium–256 has a half-life of three hours. Also, if fermium–258 has a half-life of as much as an hour, then fermium–259 can be formed from it in such a reactor. Fm–259 should be a beta emitter which will decay to mendelevium–259. The next mendelevium isotope, 260, should be a beta emitter also, decaying to nobelium–260.

Joint U.S.-Euratom Programme for Nuclear Power Stations

The Commission of the European Atomic Energy Community (Euratom) and the U.S. Atomic Energy Commission has announced that private or governmental organisations within the Community have been invited to submit " second round " proposals for the construction of large-scale nuclear power plants to be brought into operation not later than December 31, 1965. A date of June 1, 1962, has been established for submission of proposals. The member countries of Euratom are Belgium, West Germany, France, Italy, Luxembourg, and the Netherlands.

This invitation is the second issued to implement the 1958 Agreement for Co-operation between the United States and Euratom for the development of peaceful uses of atomic energy. The agreement establishes a joint nuclear power programme intended to bring large-scale power plants into operation within the Euratom Community. Nuclear reactors used are to be types on which research and development has been carried to an advanced stage in the United States. Under the First Euratom invitation issued on April 13, 1959, one proposal, that of the Italian utility (S.E.N.N.), was accepted and the 150 MW(e) boiling water reactor is now under construction near the mouth of the Garigliano River in Italy.

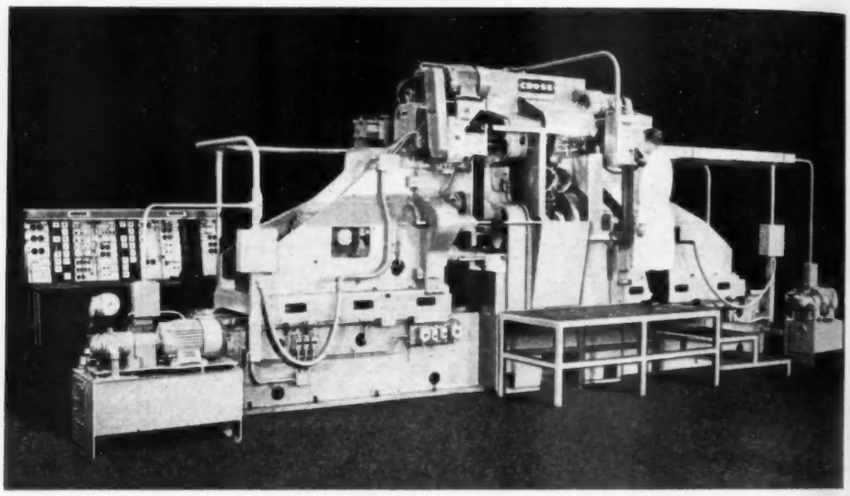
For a reactor project to be acceptable under the terms of the second invitation, there must be reasonable assurance that the plant involved can be built and brought into operation by December 31, 1965, and can thereafter be operated for ten years as a source of safe and reliable power. Preference will be given to proposals for reactor plants having a nuclear capacity of at least 140 MW(e) net, although smaller plants will be considered if they present some special interest for the programme. Under the Joint U.S.–Euratom programme, nuclear power plants must be built, owned, and operated by enterprises in the Community. Special nuclear material to fuel the nuclear plants will be made available to Euratom on either a lease or deferred payment sale basis at the option of each enterprise. The option of lease is conditioned on future amendment of the U.S.-Euratom Joint Programme Agreement. Euratom will retain control over the fuel made available to an enterprise and will also retain title to fuel which it purchases under the option. Under the terms of the joint programme, special benefits are available to projects selected for participation, including financial guarantees for a ten-year operating period with respect to fabrication cost and integrity of the fuel elements required, long-term capital loans to cover a portion of the costs associated with plant construction, and long-term assurance of an adequate nuclear fuel supply at prices comparable to those offered to U.S. industry.

The second Euratom invitation provides for more inclusive fuel element guarantees than were incorporated in the first invitation. Previously the guarantees related mainly to water-cooled reactors and covered only the uranium-dioxide fuel elements clad either in stainless steel or zirconium. In addition, the second invitation provides guarantees for metallic uranium molybdenum-aluminium elements, thus extending the coverage to types of elements which are expected to be proposed for organic-cooled power reactors. The programme also assures, over a ten-year period, a market for plutonium recovered from the reactors and provides long-term assurance by the U.S. that chemical reprocessing services will be available on the same terms offered to U.S. reactor operators.

In order to improve the overall operative and economic aspects of these nuclear power plants and in particular to assist in decreasing the unit cost of power generated, the Commission of the European Atomic Energy Community and the U.S. Atomic Energy Commission also are conducting a joint ten-year research and development programme centered on the reactors included in the programme. Information developed under this programme will be available to the industry and electricity producers of Euratom countries and the United States. The Invitation and Supplemental Fact Sheet, as well as other pertinent information, can be obtained from the European Atomic Energy Community, 51, rue Belliard, Brussels, and from the Division of International Affairs, U.S. Atomic Energy Commission, Washington 25, D.C.

Versatile Automatic Trunnion Machine

To meet production requirements of different designs of workpieces made of different materials, the Cross Company, of Detroit, Michigan, has introduced new operating flexibility into trunnion machines. These new automatic machines handle families of parts, perform a greater variety of operations, provide greater accuracy and result in higher production. A typical application of the new design of trunnion is in the manufacture of remote-accessory cylinders for tractors. The cylinders, which differ in both size and material, are rough-, semi-finish-, and finish-bored, and faced. Drilling, counterboring, chamfering, tapping and grooving operations are also done in this ten-station machine.



Cross automatic trunnion machine for the production of hydraulic cylinders

Two main heads and four auxiliary heads carry all the cutting tools. Similar operations, such as boring, drilling, counterboring and chamfering, are performed by spindles carried in the main heads. Dissimilar operations, such as tapping and facing, are accomplished by auxiliary heads, which are related to the main heads in different ways. The tapping heads are carried into the tapping position by the main heads but have their own motors to drive the individual leadscrew spindles. The spindles of the facing heads are driven from the main heads but are positioned on massive guide bars carried in the trunnion supports. This arrangement provides a minimum of overhang between the facing tools and their supports, resulting in maximum accuracy. Facing is done both ends of the cylinders with generating tools.

Single clamping of the workpiece, precision indexing of the trunnion, and boring bars that are accurately guided in the trunnion supports lead to the maintenance of close tolerances. Unusual flexibility is provided in this machine. In order to accommodate the different lengths of cylinders, it is merely necessary to change some of the tools, replace a few fixture details and adjust the feed strokes by means of dogs. In addition, because the cylinders are made of both nodular and gray iron, all speeds and feeds are adjustable. This permits the best cutting conditions to be selected for both workpiece materials. All of these changes can easily be made by one man in about half an hour.

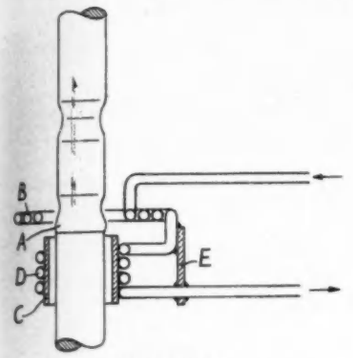
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

ELECTRONICS

876,466. June 17, 1960.—HEAT-TREATING A ROD OF SEMICONDUCTOR MATERIAL, Siemens-Schuckertwerke, Aktiengesellschaft, Berlin and Erlangen, Germany.

The known processes for heat-treatment of semiconductor material have been carried out, *inter alia*, with the rods vertical and with the material in the molten zone supported only by surface forces. If the quantity of material situated within the molten zone is too great, rupturing of the surface occurs and the molten material drips away. As a result of this, it is not usually practicable to carry out the process if the diameter of the rod exceeds a certain value. However, if the molten zone can be substantially shortened, this danger can be reduced and the treatment of rods of relatively large diameter then becomes a practical proposition. According to the present invention there is provided a method of heat-treating a rod of semiconductor material, wherein the rod is disposed with its axis vertical and a portion is encircled by a coil having a closed ring of electrically conductive material below it and encircling the semiconductor rod. In the diagram the molten zone *A* is



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shown whilst the heating coil *B* is moving downward. A closed ring *C* consisting of a short hollow cylinder is fixed to the heating coil *B* and disposed below it. The ring is provided with a cooling coil *D* which is included in the cooling circuit for the heating coil, but is not electrically connected in series with the latter, since it is bridged by means of a short-circuiting strap *E* which ensures that the heating current of the coil *B* does not flow through the ring. The length of the molten zone is reduced by the provision of the ring *C* and there is a reduction in the size of the lower bulge in the molten zone. By shortening the zone in the manner described above, it becomes safe to cause it to travel downwardly in many cases where it would otherwise be impracticable to do so. As regards the process of equalising the impurity concentration, it is no longer necessary to invert the rod after half of the passages of the molten zone along it.—*September* 6, 1961.

ELECTRIC TRACTION

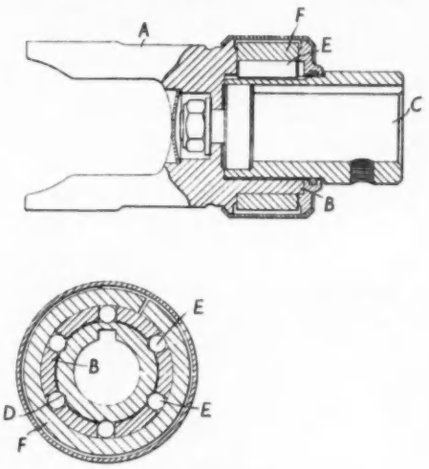
876,726. May 4, 1959.—CONTROL SYSTEMS FOR ELECTRIC MOTORS, Clark Equipment Co., Buchanan, State of Michigan, U.S.A.

This invention relates to control systems for electric motors and more particularly to improved hydraulic means for operating a varible resistor in a control circuit for an electric drive motor as employed, for example, in electrically powered industrial lift trucks, or like vehicles. The specification describes an hydraulic system for varying the pressure on the discs of a carbon pile regulator, in accordance with the driver's operation of a pedal, to provide both acceleration and reverse current braking of the vehicle. For full-speed running the regulator is by-passed and approximately half the motor field is shorted out. If the pedal is depressed too rapidly, hydraulic fluid being transmitted to the actuator of the carbon pile regulator is stored momentarily in an accumulator. A needle valve sets a predetermined time delay, or rate of flow, for the fluid to the actuator so as to limit the rate of acceleration of the vehicle. The reverser handle may be operated while the vehicle is travelling forward. Reversal of the motor current does not take place, however, until the accelerator pedal has been raised. If the motor is then still rotating in a forward direction, current flows in opposition to the battery current in a circuit which causes the flow of fluid to be transferred to the hydraulic accumulator. On renewed operation of the accelerator pedal, the accumulator acts as a secondary actuator to compress the carbon pile, thus varying the reverse braking torque in response to the hydraulic pressure applied by accelerator pedal operation. An "anti-plugging" interlock prevents application of the full battery load across the motor when its armature is rotating in an opposing direction.—*September* 6, 1961.

POWER TRANSMISSION

876,592. January 23, 1959.—TORQUE LIMITING CLUTCHES, Birfield Engineering, Ltd., Stratford House, Stratford Place, London, W.1. (*Inventor: William Cull.*)

The construction illustrated provides a torque limiting clutch which takes up very little space, both axially and radially, when used in a drive employing a universal joint. The yoke *A* has the usual jaws for interconnection with two opposed journal pegs of a star member of the universal joint. The yoke has an axially bored tubular or sleeve portion *B* which is a running fit on a reduced end of a central tubular clutch member *C*. The yoke and the central member conveniently comprise driving and driven members of the clutch. The driven member is provided at six



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equiangularly disposed positions with shallow substantially V-shaped grooves *D*. The sleeve is provided with six corresponding slots in each of which is received an elongated cylindrical roller *E* of greater diameter than the wall thickness of the sleeve. Around the sleeve is disposed a split spring ring *F* which acts upon the outwardly projecting portions of the rollers to press them firmly into the grooves in the outer surface of the driven member. The arrangement is such that, with the rollers seated in their grooves, their outer peripheral portions lie flush with the outer periphery of the sleeve. In use the transmission of torque in either direction between the members *A* and *C* will tend to displace the rollers outwards against the resistance of the spring ring. If the limiting torque is exceeded each roller is pushed out of its groove and slipping of the clutch occurs. During slipping the rollers roll around the tubular member and inside the spring ring.—*September* 6, 1961.

COLD ROLLING MILLS

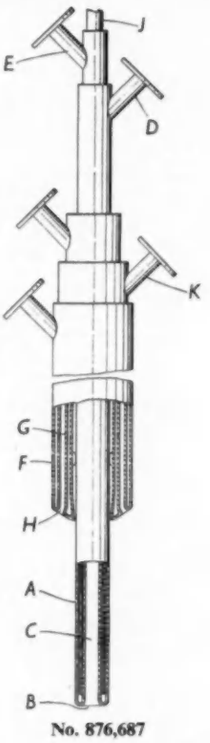
876,342. February 5, 1958.—TENSIONING MECHANISMS, National Research Development Corporation, 1, Tilney Street, London, W.1. (*Inventor: Harold Maxfield.*)

This invention has particular, but not exclusive, reference to mechanisms for applying tension to metal strip passing through a cold rolling mill. In cold rolling metal strip it is usual to apply tension to strip both entering and leaving the mill and this may be achieved by the well-known "dancer rolls." Tension is applied to the strip by weighted rollers or pulleys round which the strip passes. To apply high tension to the strip heavy weights are used and some form of safety device must be incorporated to prevent damage in the event of breakage of the strip. It is an object to provide tensioning mechanism having an improved safety device which is quick acting and sure. The tensioning mechanism described and illustrated in this specification comprises means for imparting tension, a braking mechanism for locking the tension imparting means against movement and means responsive to breakage for bringing the braking mechanism into operation.—*August* 30, 1961.

STEEL MAKING

876,687. June 24, 1960.—LANCE FOR BLOWING FLUIDS, The Wellman Smith Owen Engineering Corporation, Ltd., Parnell House, Wilton Road, London, S.W.1. (*Inventor: Gavin Smellie McLay.*)

It is known practice to refine pig iron in a top-blown converter by projecting oxygen on to the surface of the molten metal. A process of rapid slag formation is desirable for rapid phosphorus removal and this is best achieved with the aid of an oxygen jet which diffuses over an area of the bath surface, whereas carbon is more efficiently removed by a higher velocity jet which penetrates deeply into the metal. Thus a different form of jet action is called for according as to whether priority is to be given to phosphorus or carbon removal. In practice a compromise is made by varying the height of the lance above the bath, and/or by varying the velocity of the oxygen and the amount of lime injected. It is an object of the invention to provide a lance with which a greater measure of control over the relative rates of phosphorus and carbon removal can be exercised and which can produce the conditions necessary for both carbon and phosphorus removal simultaneously. The lance illustrated comprises an inner tubular water-cooling



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jacket *A* formed at its outer end with a blowing nozzle *B* and a channel *C*, water being passed through the jacket by way of an inlet *D* and an outlet *E*. The inner water-cooling jacket is partially surrounded by two outer tubular water-cooling jackets *F* and *G* which are formed with an annular channel terminating in angularly spaced nozzles *H*. A fluid such as oxygen gas is passed to the inner channel *C* through an inlet *J* and the same or a different fluid is passed to the channel to nozzles *H* through an inlet *K*. The distance by which the inner jacket projects from the end of the two outer jackets may be fixed to give correct conditions for carbon removal in relation to oxygen velocity, height above the bath and, if desired, lime injection, whilst the outer lance is designed to give correct conditions for phosphorus removal in relation to oxygen velocity, height above the bath and lime injection. Alternatively the inner jacket may be made movable relatively to the two outer jackets.—*September* 6, 1961.

Catalogues and Brochures

BROWN, LENOX AND CO. LTD., Pontypridd, Glamorgan.—Brochure entitled "Steel Castings," giving notes on the range of castings produced by the company, from 3½ tons down to 56 lb as a normal limit; castings smaller than this in certain circumstances. A simple steel selection guide is given, followed by more detailed information on steel specifications, machining and sub-assembly work. A glossary of metallurgical and steel foundry terms is also given.

LODGE PLUGS LTD., Rugby.—Folder detailing properties and applications of Lodge hermetic metal/ceramic brazed seals. These are high-temperature, high-strength assemblies, incorporating high-conductivity copper, matched metals and 95 per cent alumina from the "Sintox" range of ceramics. Examples are illustrated of rectifier housings, cable terminations, aircraft terminal blocks and fire detection equipment, and high-temperature plugs and sockets embodying the seals.

THOS. FIRTH AND JOHN BROWN LTD., P.O. Box No. 114, Atlas Works, Sheffield, 4.—Publication No. 234, entitled "Works and Products." This booklet, illustrated in black and white and colour, gives a brief chronological list of events in the history of the company and its two predecessors, Thos. Firth and Sons and John Brown and Company. It goes on to describe the firm's steel melting, forging, rolling, heat treatment, machinery and heavy engineering facilities, and lists the principal products. A list of home and overseas offices and agents is also given.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office no later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Mon., Oct. 23.—BRISTOL AND WEST OF ENGLAND BRANCH: Grand Hotel, Bristol, Film, 8 p.m. ★ OXFORD AND DISTRICT BRANCH: Reactor School, A.E.R.E., Harwell, "Servo-mechanism Components and their Applications," 7.30 p.m.
Tues., Oct. 24.—BRADFORD AND DISTRICT BRANCH: Visit to Landis Lund, Keighley, 7.15 p.m.
Wed., Oct. 25.—BIRMINGHAM BRANCH: Visit to Stewarts and Lloyds Ltd., Bilston Iron and Steel Works, Bilston, Staffs, 7 p.m.
Thurs., Oct. 26.—SOUTH LONDON BRANCH: Greyhound Hotel, Croydon, Surrey, "Navigation Lights: Manufacture and Servicing," A. F. Burn, 8 p.m. ★ SOUTHAMPTON BRANCH: Polygon Hotel, Southampton, "The Practical Application of the New I.E.S. Code," P. G. Merritt, 8 p.m.
Fri., Oct. 27.—COVENTRY AND DISTRICT BRANCH: Conservative Rooms, 16, Queens Road, Coventry, "The Revision of British Standards and their Effect on Motor Applications," F. T. Bartho, 8 p.m. ★ STOKE AND CREWE BRANCH: Royal Hotel, Crewe, "The Lighting of Offices," D. Whipp, 7.30 p.m.

BRITISH INSTITUTE OF MANAGEMENT

Tues. to Thurs., Oct. 24 *to* 26.—Torquay, 1961 National Conference, to be opened by S. P. Chambers.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Oct. 25.—COMPUTER GROUP: London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, Symposium on "Digital Differential Analysers," 6 p.m. ★ EAST MIDLANDS SECTION: The University, University Road, Leicester, "Achieving High Reliability in Electronic Equipment," N. B. Griffin, 6.45 p.m.
Thurs., Oct. 26.—WEST MIDLANDS SECTION: Electrical Engineering Dept., The University, Birmingham, "Instruments for the First U.K. Scout Satellite," J. Sayers, 6.15 p.m.

CEMENT AND CONCRETE ASSOCIATION

Mon., Oct. 23.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Building Methods in Sweden," B. Axelson, 6 p.m.
Tues., Oct. 24.—City of Canterbury College of Art, St. Peters Street, Canterbury, "Building High" N. Wakefield, 7.15 p.m.
Wed., Oct. 25.—Scottish Building Centre, Glasgow, "Fire Resistance of Concrete Structures," M. R. Hollington, 7.15 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Oct. 23.—BIRMINGHAM CENTRE: Chamber of Commerce, 75, Harborne Road, Edgbaston, Birmingham, 15. "Floodlighting in Colour," J. W. Bessant, 6.30 p.m. ★ LEEDS CENTRE: British Lighting Council, 24, Aire Street, Leeds, 1, "Office Lighting," R. G. Hopkinson, 6.15 p.m. ★ LEICESTER CENTRE: Demonstration Theatre, East Midlands Electricity Board, Charles Street, Leicester, "The New I.E.S. Code," W. E. Harper, 6.15 p.m.
Tues., Oct. 24.—LIVERPOOL CENTRE: Industrial Development Centre, Paradise Street, Liverpool, "The New I.E.S. Code," H. E. Bellchambers, 6 p.m. ★ LONDON BRANCH: Visit to Hirst Research Centre, G.E.C. Ltd., Wembley, 5 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Thurs., Oct. 26.—LONDON BRANCH: National Liberal Club, Whitehall Place, London, S.W.1, "Gating for the Production of High Duty Iron Castings," L. Clarke, 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Tues., Oct. 24.—MERSEYSIDE AND NORTH WESTERN SECTION: Technical College, Bolton, "Boiler Water Treatment," 3.15 p.m. ★ Memorial Building, 76, Mark Lane, London, E.C.3, "Electrostatic Charging During the White Oil Loading of Tankers," M. P. Holdsworth, Dr. J. L. Van der Minne and S. J. Vellenga, 5.30 p.m.
Wed., Oct. 25.—SCOTTISH SECTION: Weir Hall, Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "Elementary Nuclear Engineering," H. F. Close, 7.30 p.m. ★ NORTH MIDLANDS SECTION: British Iron and Steel Research Association Building, Hoyle Street, Sheffield, "Heatless Repairs to Fractured or Broken Castings," N. Tinwell, 7.15 p.m.
Fri., Oct. 27.—SOUTH WALES SECTION: Technical College, Mount Pleasant, Swansea, Brains Trust, 6 p.m.

INSTITUTE OF METALS

Wed., Oct. 25.—MANCHESTER METALLURGICAL SOCIETY: Manchester Literary and Philosophical Society, George Street, Manchester, Discussion on "Education in the Metallurgical Field," L. W. Berry, H. O'Neill and D. R. O. Thomas, 6.30 p.m.
Thurs., Oct. 26.—BIRMINGHAM LOCAL SECTION: College of Advanced Technology, Gosta Green, Birmingham, Presidential Address to the Birmingham Metallurgical Society, S. Heslop, 6.30 p.m. ★ SOUTHAMPTON METALLURGICAL SOCIETY: The University, Southampton, "Metallurgy of Uranium," J. J. Stobo, 7.15 p.m.

INSTITUTE OF NAVIGATION

Wed., Oct. 25.—DUKE OF EDINBURGH'S LECTURE: Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Navigation and the Science of the Sea," G. E. R. Deacon, and Annual General Meeting, 3 p.m.

INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

Tues., Oct. 24.—STRESS ANALYSIS GROUP: 47, Belgrave Square, London, S.W.1, "The Nature of Stress Raisers," 2.30 p.m.
Wed., Oct. 25.—YORKSHIRE BRANCH: The University, Hull, "Nuclear Magnetic Resonance in Solids," E. R. Andrews, 5 p.m.
Thurs., Oct. 26.—LONDON AND HOME COUNTIES BRANCH: 47, Belgrave Square, London, W.1, "The Riddle of the Lower Stratosphere," A. W. Brewer, 6 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., Oct. 23.—SCOTTISH CENTRE: North British Hotel, Edinburgh, "Materials Handling—Its Equipment and Maintenance," D. MacDonald Walker, 7.30 p.m.
Thurs., Oct. 26.—NORTHERN CENTRE: Commercial Hotel, Accrington, "Servicing of Electrical Equipment," H. J. Stoneman, 7.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., Oct. 24.—NORTH WESTERN BRANCH: Chemical Engineering Lecture Theatre, Manchester College of Science and Technology, Jackson Street, Manchester, "Work Study in Relation to Chemical Engineering Design," 5.30 p.m. ★ NORTH WESTERN BRANCH: Blossoms Hotel, Chester, "The Significance of Operating Lines in Distillation Systems," W. H. Granville, 7.30 p.m.
Thurs., Oct. 26.—NORTH EASTERN GROUP: Research Lecture Theatre, Imperial Chemical Industries Ltd., Billingham, "Computers in an Oil Refinery," D. G. Thompson, 5.45 p.m.
Fri., Oct. 27.—SCOTTISH BRANCH: Royal College of Science and Technology, Glasgow, "Problems in Evaporation," H. D. MacMurray, 7.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues. Oct. 24.—Great George Street, Westminster, London, S.W.1, "New Premises for the North Thames Gas Board, Fulham," A. J. Leggatt and J. Bobrowski, 5.30 p.m.
Thurs., Oct. 26.—TRAFFIC ENGINEERING GROUP: Great George Street, Westminster, London, S.W.1, Discussion on "Practical Traffic Surveys," introduced by B. L. Allen, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Sat., Oct. 21.—LONDON GRADUATE AND STUDENT SECTION: Visit to the Medical Research Council, 10 a.m.
Mon., Oct. 23.—Savoy Place, London, W.C.2, Discussion on "Is Automation Making Satisfactory Progress?" opened by A. Justin, 5.30 p.m. ★ EAST ANGLIAN SUB-CENTRE: Assembly House, Norwich, "British Nuclear Power To-day," A. L. Shaw, 7.30 p.m. ★ MERSEY AND NORTH WALES CENTRE: Town Hall, Chester, "Technical and Economic Aspects of the Supply of Reactive Power in England and Wales, W. Casson and H. J. Sheppard, 6.30 p.m. ★ NORTH EASTERN CENTRE: Neville Hall, Westgate Road, Newcastle upon Tyne, "Silicon Power Rectifiers," A. J. Blundell, A. E. Garside, R. G. Hibberd and I. Williams, 6.15 p.m. ★ NORTH WESTERN CENTRE: Royal College of Advanced Technology, Salford, Discussion on "How Long Do We Go On Teaching our Subject Historically?" opened by E. R. Laithwaite, 6.15 p.m. ★ SOUTH MIDLAND ELECTRONICS AND MEASUREMENT GROUP: James Watt Memorial Institute, Birmingham, "Space-Charge-Limited Dielectric Devices—Successors to the Transistor?," G. T. Wright, 6 p.m. ★ NORTH STAFFORDSHIRE SUB-CENTRE: N. Staffs. College of Technology, Stoke-on-Trent, "The Development of Communication, Indication and Telemetering Equipment for the British Grid," G. A. Burns, F. Fletcher, C. H. Chambers and P. F. Gunning, 7 p.m. ★ WESTERN UTILISATION GROUP: S.W.E.B. Demonstration Theatre, Bristol, "Research in the Field of Electricity Utilisation," H. G. Taylor, 6 p.m.
Tues., Oct. 24.—MEASUREMENT AND CONTROL SECTION: Savoy Place, London, W.C.2, "The Use of Analogue Computers in Predicting the Space-Time Behaviour of Nuclear Reactors," R. W. Hockney and T. O. Jeffries, 5.30 p.m. ★ NORTH WESTERN SUPPLY GROUP: Engineer's Club, Manchester, "A General Method of Digital Network Analysis particularly suitable for Use with Low-Speed Computers," M. N. John, and "Digital Computers in Power System Analysis," P. P. Gupta and M. W. Humphrey Davies, 6.15 p.m. ★ SOUTH EAST SCOTLAND SUB-CENTRE: Carlton Hotel, North Bridge, Edinburgh, Sub-Centre, Chairman's Address, W. E. J. Farvis, 7 p.m.
Wed., Oct. 25.—ELECTRONICS AND COMMUNICATIONS SECTION: Savoy Place, London, W.C.2, Chairman's Address, "Global Communication," R. J. Halsey, 5.30 p.m. ★ LONDON GRADUATE AND STUDENT SECTION: Visit to the Micanite and Insulators Co. Ltd., 2.15 p.m. ★ NORTH LANCASHIRE SUB-CENTRE: N.W.E.B. Demonstration Theatre, Duke Street, Barrow, "Submersible Pumping Plant," H. H. Anderson and W. C. Crawford. ★ RUGBY SUB-CENTRE: College of Engineering Technology, Rugby, "Electric Ship Propulsion with Special Reference to S. S. Canberra," L. W. W. Graham, 6.30 p.m. ★ SOUTHERN CENTRE: King's Arms Hotel, Christchurch, "The Transmission of Speech through Narrow Bandwidths," L. G. Stead, 6.30 p.m.
Thurs., Oct. 26.—ORDINARY MEETING: Savoy Place, London, W.C.2, "A Comparison between Generation and Transmission Problems in Great Britain and France," P. M. J. Ailleret, 5.30 p.m. ★ NORTH SCOTLAND SUB-CENTRE: Electrical Engineering Department, Queen's College, Dundee, Sub-Centre Chairman's Address, G. L. Doig, 7 p.m. ★ SOUTH MIDLAND CENTRE: College of Technology, Gosta Green, "Some Recent Developments in Electro Heat," E. May, 6.15 p.m. ★ SOUTHERN CENTRE: Technical College, Farnborough, "A General Theory of Depreciation of Engineering Plant, D. Rudd, 6.30 p.m.
Fri., Oct. 27.—NORTH SCOTLAND SUB-CENTRE: Robert Gordon's Technical College, Aberdeen, Sub-Centre Chairman's Address, G. L. Doig, 7.30 p.m. ★ SOUTHERN CENTRE: S.E.B. Showrooms, Newport, I.O.W., "Safety in the Utilisation of Electricity," S. J. Emerson, 6.30 p.m. ★ SOUTHERN CENTRE: South Dorset Technical College, Weymouth, "The Psychology of Study," C. A. Mace, 6.30 p.m.
Sat., Oct. 28.—LONDON GRADUATE AND STUDENT SECTION: Visit to British Railways Signalling School, Clapham Junction, 2.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Oct. 24.—39, Elmbank Crescent, Glasgow, "The Atom in the Future," W. R. Wootton, 6.30 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS

To-day, Oct. 20.—MANCHESTER AND DISTRICT BRANCH: Engineers' Club, Albert Square, Manchester, "Air Conditioning of Operating Theatres," R. Blowers, 6.30 p.m.
Tues., Oct. 24.—SCOTTISH BRANCH: Scottish Building Centre, 425, Sauchiehall Street, Glasgow, C.2, Discussion on "The Heating of Buildings by Off-Peak Electricity Supplies," 7 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Tues., Oct. 24.—Lecture Hall, Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, "Control of Diesel Electric Locomotives," O. Schlaepfer, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Mon., Oct. 23.—EAST MIDLANDS BRANCH: Room 104, College of Technology and Commerce, Leicester, Repetition of James Clayton Lecture, "Machine Tool Research, Design and Utilisation," D. G. Galloway, 7.15 p.m.
Tues., Oct. 24.—EASTERN BRANCH: Dujon Restaurant, Bedford, Discussion on "Theory and Practice of Management," 7.30 p.m. ★ RUGBY SUB-BRANCH: College of Engineering Technology, Rugby, "Some Features of the Design and Operation of Castle Donnington Power Station," J. O. Grieve, A. H. Parish and J. S. Hall, 6.30 p.m. ★ WESTERN CENTRE: Royal Hotel, Bristol, Repetition of Chairman's Address, 6.45 p.m. ★ EAST MIDLANDS GRADUATES' BRANCH: College of Further Education, Loughborough, "Electricity in the Water Supply Industry," 7.15 p.m.
Wed., Oct. 25.—ORDINARY MEETING: 1, Birdcage Walk, Westminster, London, S.W.1, Presidential Address, "Co-ordination of Engineering Research and the Conservation of Scientific and Technical Manpower," Sir Kenneth Hague, 6 p.m. ★ YORKSHIRE BRANCH: Afternoon visit to Distillers Co. Ltd., Chemical Division, Saltend, Hull; and at "The Royal" Station Hotel, Hull, "Corrosion and Mechanical Engineering in a Chemical Plant," E. T. Smith, 7.45 p.m.
Thurs., Oct. 26.—NORTH EASTERN BRANCH: Stephenson Building, Claremount Road, Newcastle upon Tyne, "The Design of Modern Boiler Feed Pumps," H. H. Anderson, 6.15 p.m. ★ NORTH WESTERN BRANCH: College of Science and Technology, Manchester, Discussion on "The Effect of Ambient Conditions on the Performance of Turbo-charged Diesel Engines," 6.45 p.m. ★ SOUTHERN BRANCH: Technical College, Farnborough, "A General Theory of Depreciation of Engineering Plant," D. Rudd, 6.30 p.m.
Mon., Oct. 30.—THERMODYNAMICS AND FLUID MECHANICS GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "The Extent to which the Institution should Contribute to the Availability of Design Data and Information in Thermodynamics and Fluid Mechanics," 6 p.m.

INSTITUTION OF PLANT ENGINEERS

Tues., Oct. 24.—SOUTH WALES BRANCH: South Wales Institution of Engineers, Park Place, Cardiff, Film, "Clean, Correct and Careful," 7.30 p.m.
Thurs., Oct. 26.—NORTH EAST BRANCH: Three Tuns Hotel, Durham City, "Engineering at Coal Mines," W. J. Cann, 7 p.m.
Fri., Oct. 27.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, "High Pressure Hot Water Heating," P. Marshall, 7.30 p.m.
Mon., Oct. 30.—WEST AND EAST YORKSHIRE BRANCH: Hendsworth School of Applied Science, The University, Leeds, "British Development of Hovercraft," R. A. Shaw, 7.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., Oct. 23.—NORTH MIDLANDS REGION: Louis Room, St. James's Restaurant, St. James's Street, Derby, "Spark Machining as an Aid to Production," S. V. Divers, 7 p.m.
Wed., Oct. 25.—NORTH WESTERN REGION: Reynolds Hall, Manchester College of Science and Technology, Sackville Street, Manchester, "Explosive Forming," W. S. Hollis, 7.15 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Tues., Oct. 24.—WALES AND MONMOUTHSHIRE BRANCH: South Wales Institute of Engineers, Park Place, Cardiff, Chairman's Address, E. Hughes, 6.30 p.m.
Thurs., Oct. 26.—LONDON BRANCH: 11, Upper Belgrave Street, London, S.W.1, "The Plastic Design of Latticed Portal Frames," B. H. Fisher, Jacques Heyman and L. G. Jaeger, 6 p.m.
Fri., Oct. 27.—MIDLAND COUNTIES BRANCH: Byng Kenrick Suite, College of Advanced Technology, Birmingham, Chairman's Address, "Concrete—Past, Present and Future," J. E. C. Farebrother, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Oct. 20.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Recent Trends in Telecommunications," R. A. Hill, 7 p.m.
Fri., Oct. 27.—Pepys House, 14, Rochester Row, Westminster, S.W.1, "The Influence of Aeroplane Design on the Economics of Air Transport," G. H. Lee, 7 p.m.

JOINT COMMITTEE ON STRUCTURAL CONCRETE

Mon., Oct. 23.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Methods of Housing Construction in Sweden," Bengt Axelson, 6 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Mon., Oct. 30.—ANDREW LAING LECTURE: Literary and Philosophical Society's Lecture Theatre, Newcastle upon Tyne, "Aspects of Research in Marine Engineering," A. W. Davis, 6.15 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN

Fri., Oct. 27.—21, Albemarle Street, London, W.1, "Cosmic Rays from the Sun," M. A. Ellison, 9 p.m.

SOCIETE DE CHIMIE INDUSTRIELLE

To-day, Oct. 20.—Maison de la Chimie, Paris, Symposium on "Corrosion in the Nuclear Energy Industry."

SOCIETY OF ENVIRONMENTAL ENGINEERS

Wed., Oct. 25.—Imperial College Mechanical Engineering Department, Exhibition Road, London, S.W.7, "Structures and Components at Elevated Temperatures," A. M. P. Brooton, 6 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Wed., Oct. 25.—DATA PROCESSING SECTION: Manson House, 26, Portland Place, London, W.1, "Mechanising Factory Shop Floor Form Filling," 6.30 p.m.